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NODIA EDITIONS LLP
125, Sector 6, Vidyadhar Nagar, Jaipur 302039
Phone :+91 9024037387
email : mail@nodia.in

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Assistant Professor Exam-2025
Second Paper
Syllabus- Botany

UNIT-I: Biology and diversity of lower plants

- Virology: General account of viruses; characteristics, ultra structure; chemical nature, replication, transmission, viral disease and symptoms of viral infections and control. TMV and Bacteriophages, Viroid, virusoids and Prions, Plasmids, Actinomycetes, mycoplasma, Rickettsia, Chlamydia.
- Bacteriology: General account of Archebacteria and Eubacteria: ultra-structure, nutrition, reproduction and economic importance. Salient features and biological importance of Cyanobacteria.
- Mycology: General characteristics and classification of fungi, cellular organization, and cell wall composition, nutrition, reproduction, Heterokaryosis, Heterothallism, and Parasexuality.
    - General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
- Economic importance of Fungi; Mycorrhiza, fungal disease in plants and humans, host parasite relationship, mycotoxins, Plant pathology and important plant diseases of M.P. General account of Lichens.
- Phycology: General characteristics and classification of algae, Habit and Habitat, Thallus organization, criteria for classification of algae; cell ultrastructure, Reproduction, flagellation, pigmentation, Reserve food materials. Economic importance of algae, Algal blooms.
    - General account of Prochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta.

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UNIT-II: Biology and Diversity of Bryophyta, Pteridophyta and Gymnosperms

- Bryophyta: General characteristics and classification of Bryophyta, Distribution, Study of Morphology, anatomy and Reproduction, General characteristics and classifications of Hepaticopsida, Anthocerotopsida and Bryopsida. Ecological and Economic Importance of Bryophyta.
- Pteridophyta: General characteristics and classification of Pteridophytes Morphology, anatomy; life history of Pteridophytes, Evolution of stele, Heterospory and origin of seed habit. Economic importance of Pteridophytes.
- General Characteristics features, Anatomy, Life history, Alternation of generations of Psilopsida, Lycopsida, Sphenopsida and Pteropsida.
- Gymnosperms: General Characteristics and classifications of Gymnosperms. Distribution of Gymnosperms in India, evolutionary tendencies among Gymnosperm and economic importance of Gymnosperms: Indian Contribution to gymnosperms. Geographical time scales and fossilization.
- General account of Pteridospermales, Cycadeoidales, Cordaitales, Cycadales, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales.

UNIT-III: Morphology and Taxonomy of Angiosperms

- Origin and evolution of angiosperms, Floral Induction and development, morphology of stamens and carpels, and their evolution, Placentation their origin, types and evolution, Morphology of Angiospermic plant parts.

- Concept of species, Hierarchical, Salient feature of International code of Botanical nomenclature, Taxonomic tools and Techniques: Floras, Botanical garden, Museum, Taxonomic key, Taxonomic Literature, Histological, Biochemical, Cytological, Phytochemical, Serological and molecular techniques.
- Systematics of Angiosperm classifications(Natural and Phylogenetic) their relative Merits and Demerits, Modern Trends in Taxonomy, Morphology, Anatomy, Palynology, Embryology, Cytology and Phytochemistry, Including Molecular taxonomy and GIS, APG IV system, Endemism.
- Terminology for plants Description in semi technical language, Diagnostic characteristics and economic importance of Ranunculaceae, Brassicaceae, Papaveraceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Magnoliaceae, Rosaceae, Dipterocarpaceae and Cucurbitaceae.
    - Diagnostic characteristics and economic importance of Rubiaceae, Asteraceae, Apocynaceae, Acanthaceae, Asclepiadaceae, Solanaceae, Verbenaceae, Lamiaceae, Euphorbiaceae.
- Diagnostic characteristics and economic importance of Musaceae, Liliaceae, Araceae, Poaceae, Orchidaceae. General characteristics and phylogeny of Ranales, Amentiferae, Tubiflorae, Santalales, Centrospermae and Hellebiales.

UNIT-IV: Developmental Biology: Morphogenesis and Organogenesis in Plants

- Meristematic Tissue, Classification of meristems Root System: Root Apical meristems, Tissue differentiations of Primary and Secondary Tissue, and their role. Anatomy of Dicot and Monocot Root, Secondary growth in Root, Modification of root for various functions. Root interaction with Microbes.
- Organization of shoot apical Meristems, Histological organization, Shoot Development, Modifications of shoot for different functions, Anatomy of Dicot and monocot Stem, Vascular cambium and its function, Secondary growth Stem, growth rings, Sap wood and Heart wood, Secondary phloem, cork cambium and periderm. Anomalous structure (Primary and Secondary Anomalous structure).
- Leaf: Origin and development of leaf, diversity in size, shape and arrangement (phyllotaxy), Anatomy of Dicot leaf and Monocot leaf. Adaptation to photosynthesis and water stress.
- Transition of Flowering, Floral meristems and floral development in Arabidopsis and Antirrhinum. Structure of Stamen, anther, Microsporogenesis and development of male gametophyte, Structure of pistil, Structure and types of ovules, Megasporogenesis, and Development of female gametophyte,(embryo sac and its type), Pollination: Its mechanism and agencies of pollination. Self-incompatibility.
- Double fertilization and triple fusion, Development and types of Endosperms, and its morphological nature, Development of Embryo in Dicot and Monocot plants, Fruit: structure Development and Maturation, Types of Fruits, Seed structure, types Development and Dispersion,Importance of seed. Vegetative propagation and their types.

UNIT-V: Plant Physiology and Biochemistry

- Plant water relations, transpiration, Stomatal movement, Solute transport and photo assimilate Translocation; Update transport, translocation of water, ion solutes and micromolecules from soil through across membranes through xylem and phloem, mechanism of loading and unloading of photoassimilates, Mineral Nutrition.
- Photosynthesis: light harvestingcomplex, Mechanism of electron transport, Photo protective mechanism, CO_2 fixation, C3, C4 and CAM pathways.

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- Respiration and Photorespiration: Glycolysis, Citric acid cycle, plant mitochondrial electron transport system, ATP synthesis, Alternative pathways, photo respiration.
- Nitrogen Metabolism: Nitrate and Ammonium assimilation, Amino acid biosynthesis. Plants Hormones: Biosynthesis, physiological effects, mechanism of action, storage breakdown and transport; Aging and senescence.
    - Sensory photobiology: Structure, Function and mechanism of action of phytochromes, Cryptochromes and phototropins. Photoperiodism and Vernalization,Biological clock.
    - Stress physiology: Responses of plants to biotic (Pathogen and Insects) and Abiotic(Water, Temperature and Salts) Stresses, Mechanism of resistance and tolerance to biotic stress.
- Fundamentals of Enzymology: General aspects, Principles, Classification, Mechanism and Regulation of Enzymes. Allosteric mechanism, and enzyme kinetics.
  Structure, function and classifications of biomolecules: Carbohydrate, Protein, Lipids, Amino acids, nucleic acids and Vitamins
  Secondary metabolites: biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

UNIT-VI: Plant Ecology

- Community Ecology: Nature of communities, community structure and attributes; levels of species diversity and its measurements.
    - Ecological adaptations: Morphological, Anatomical and Physiological responses, Water, temperature, and Light adaptation.
    - Ecological successions: type, mechanism, changes involved in succession, concept of climax. Ecades and Ecotone.
    - Population Ecology: Characteristics of a population, Growth curve, population regulation, life history strategies (r and k selection).
- Ecosystem: Structure and Function, Abiotic and Biotic Components, Trophic levels, Food Chain, Food Web, Ecological Pyramids, energy flow and mineral cycling (C,N,S,P). Productivity, decomposition, Structure and function of Indian ecosystems, terrestrial (Forest and Grasslands), and aquatic (Fresh water, Marine, estuarine), wetlands.
- Species interaction: Biotic and abiotic interactions, interspecific competition, herbivorous, carnivorous, symbiosis and Pollination.Concept of Habitats and Niche, resource partitioning, character displacement.

UNIT-VII: Ethnobotany and Applied Botany

- Definition and scope of Ethnobotany Historical record and outline idea of Archiethnobotany, Ethnomedicine, Ethno taxonomy, Ethno ecology, Ethno orthopaedics, Ethno paediatrics, Ethnophthalmology, Ethnopharmecology, Ethnogynacology, Ethno toxicology, Ethnocosmatics, Ethnonarcotics, Ethno musicology and EthnoLinguistics.
- Prevention of Genetic Diversity, Plants used in various system of Medicines, Ayurvedic, Unani, and Homeopathic system, Allopathic system, Plants used by villagers and tribal people, Role of Ethnobotany in the development of society. Plants in Mythology, Taboos and Totem in relations to plants, Folklore and folk talks, Wildlife protection in tribal, plants domestication by the tribal, Plants in simile and metaphors.
- Ethnobotanical Importance of: Aconitum napellus, Allium cepa, Allium Sativum, Atropa belladonna, Aloe vera, Azadirachta indica, Butea monosperma, Cassia fistula, Cannabis sativa, Emblica officinalis, Eugenia aromatica,Eugenia jambolana, Holarrhena

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antidysentrica, Jatropha curcas, Lawsonia inermis, Mentha arvensis, Nux- vomica, Ocimum sanctum, Piper nigrum, Pterocarpus mrsupium, Papaver somniferum Rauvolfia serpentine, Ricinus communis, Santalum album ,Terminalia chebula,Terminalia arjuna and Terminalia belerica, Withania somnifera, Zingiber officinalis.

- Detail study of the common plants and their parts used in the treatment of following disease. Expulsion of worms, Skin disease, asthma and Bronchial inflation , Urinogenital Problem, Amoebic dysentery, Malaria, Rheumatism, Jaundice, Heart disease leukaemia ,tuberculosis, Blood purifier, piles Leucoderma,Heart Disease Leprosy.
- Applied Botany: Microbial fermentation and their importance in industrial production, Types of fermenters.
    - Plant Cell and tissue culture, Totipotancy, Aseptic and Sterilization techniques, Explant techniques of tissue culture , Meristems, Anther, Embryo culture, organo-genesis, somatic hybridization, Cryopreservation, application of Plant tissue culture. Transgenic plants, phytoremediation.
    - Economic Botany: cereals, pulses, fibres, oil yielding and drug yielding plants with special reference to Madhya Pradesh.

UNIT-VIII: Cell biology and Evolution

- The Cell envelop, Structure and functions of cell wall, Ultra Structure and functions of Plasma membrane, different Structural model of plasma membrane, lipid bilayer and membrane protein, Diffusion, Osmosis, Ion channels, Active transport, ion pumps, mechanism of ion sorting and regulation of intracellular transport, electrical properties of membrane.
- Structure and function of cell organelles: Golgi complex, mitochondria, chloroplast, peroxisome, ribosome, Endoplasmic reticulum, Vacuole, lysosomes and nucleus.
- Structure and function of chromosome, special types of chromosome, Packaging of DNA, Karyotype, Binding Pattern, operon, interrupted gene, structure of chromatin and chromosome, unique and repetitive DNA, heterochromatin and euchromatin, Chromosome walking, transposons.
- Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle and control of cell cycle, Crossing over and linkage. Gene structure and expression, Cis and Trans test of recombination, introns, exons, and their significance.
- Structural Changes (Deletion, Duplication, Translocation, Inversion,)and numerical Changes (Aneuploidy and Polyploidy) in Chromosome, Extra nuclear Genome: Presence and function of mitochondrial and plastid DNA, Plasmid. Mendel's Law, Interaction of Gene. Polygenic inheritance.
- Evolution: Emergences of evolutionary thoughts, Lamarck, Darwin, Concepts of Variations, Adaptations, Struggle, fitness and natural selection, spontaneity of mutations, the evolutionary synthesis.

UNIT-IX: Molecular Genetics

- Nuclear DNA content, DNA structure and Forms of DNA (A, B, Z,),replication of DNA,(unit of replication, enzyme involved replication origin, fork fidelity of replication,) DNA damage and Repair, Restriction Mapping, Multigene Families and Their evolution. Recombinant DNA: C Value Paradox, Cot curve and its application.
- RNA synthesis and Processing: Transcription factors machinery, Formation of initiation complex, Transcription activators and repressors, RNA polymerases capping, elongation,

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termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

- Protein synthesis and processing: Ribosomes structure and site of protein synthesis, formation of initiation complex, initiation factor and their regulation ,elongation and elongation factors, termination, Genetic Code, amino assimilation of tRNA, tRNA identity, amino acyl tRNA synthetase, Translation Proof reading, Translation inhibitor, post translation Modification of proteins. Protein sorting, targeting of protein to organelles.
- Control of gene expression of transcription and translation level: regulation andgenetics of bacteria and virus, (genetic transformation, conjugation and transduction, Recombination in phage), Regulation of gene expression in eukaryotes, role of euchromatin in regulation of gene. Gene silencing. Gene Mutation.
- Plant breeding: In situ Hybridization, concept and techniques, genetic basis of in breeding and heterosis, exploitation of hybrid vigour, Cancer oncogene, apoptosis, immune innate and adaptive immune system.

UNIT-X: Tools, Techniques in Biology and Biotechnology

- Microscopic techniques; light microscopy, Phase contrast, Dark field Microscope, fluorescence microscopy, Electron microscope, Scanning and Transmission microscopes. Different types of fixations and staining techniques for Electron microscope. Freeze-etching and freeze fracture method for Electron microscope, image processing methods in Microscopy. Electrophoresis, Chromatography, colorimeter, pH meter, Centrifuge, Microtome and Laminar Air Flow.
- Biophysical methods: Analysis of biomolecules, using UV, Visible, Fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determining using X-RAY, Differentiations and NMR; analysis using light scattering, different types of mass spectrometry, and surface plasma resonance methods.
- Histochemical and Immunotechniques: Antibody generation, detection of molecules, using ELISA,RIA, Western Blotting, Southern Blotting, Immunoprecipitation, Flow cytometry, and Immuno detection of molecules in living cells, in situ localization by techniques such as FISH,GISH.
- In vitro mutagenesisand deletion techniques, gene knock out technology in bacterial and eukaryotic organisms,large scale expression analysis such as micro array based techniques, Isolation Separation and analysis of carbohydrate and lipid molecules, RFLP, RAPDandAFLP techniques.
    - Molecular biology and Recombinant DNA technology: methods of isolation and purification of RNA, DNA(Genomic and Plasmid)and Proteins, Different separation Methods, analysis of RNA, DNA and Proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels.
    - Molecular cloning of DNA or RNA Fragments in Bacterial and eukaryotic systems, expressions of recombinant proteins using bacterial, animal and plant vectors; Isolation of specific nucleic acid sequences; generation of genomic and c-DNA libraries in Plasmid, phage, cosmid, BAC and YAC vectors.
- Biotechnology: Principles and application of biotechnology in agriculture, horticulture, forestry, food industries, healthcare, immunology, environmental biotechnology and ethics, IPR (Intellectual Property rights) Genetic Engineering of plants, PCR,DNA finger printing.

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CHAPTER 01

Biology and Diversity of Lower Plants

1. Which of the following best defines a virus?
(A) A free-living prokaryotic microorganism with a complex cellular structure.
(B) An acellular parasite containing a nucleic acid core and protein capsid.
(C) A unicellular eukaryote with the ability to perform photosynthesis.
(D) An infectious protein agent causing various neurodegenerative conditions.

2. Identify the correct statement regarding the chemical nature of viruses.
(A) Viral genetic material consists of either DNA or RNA, but never both.
(B) All viral species contain both DNA and RNA genomes simultaneously.
(C) Viruses have specific metabolic enzymes required for ATP synthesis.
(D) The external viral envelope is primarily composed of peptidoglycan.

3. Consider the following statements:
Statement I: Viroids are infectious agents smaller than viruses.
Statement II: Viroids consist of a short, circular, single-stranded RNA molecule without a protein coat.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

4. A researcher observes an infectious agent that is composed solely of protein and causes a spongiform encephalopathy. This agent is most likely a:
(A) Bacteriophage
(B) Viroid
(C) Mycoplasma
(D) Prion

5. All of the following are methods of viral transmission EXCEPT:
(A) Through insect vectors.
(B) Through contaminated water or food.
(C) Through binary fission.
(D) Through airborne droplets.

6. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Bacteriophages are viruses that infect bacteria.
Reason (R): They replicate by injecting their genetic material into the bacterial host cell, utilizing its machinery.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

7. What is the primary function of the capsid in a virus?
(A) To synthesize viral proteins.
(B) To provide energy for the virus.
(C) To facilitate photosynthesis.
(D) To protect the viral nucleic acid.

8. Identify the incorrect statement about Mycoplasma.
(A) They act as obligate intracellular parasites.
(B) They are the smallest known free-living organisms.
(C) They lack any form of a rigid cell wall.
(D) Their plasma membrane contains sterols.

9. Which of the following is a key characteristic of the lytic cycle of a bacteriophage?
(A) The phage DNA integrates into the host chromosome.
(B) The host cell remains alive and continues to divide.
(C) The host cell is lysed to release new phage particles.

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(D) The phage remains dormant for several generations.

10. Match List I with List II regarding microorganisms and their key features:
List I: (Microorganism)
P. Prion
Q. Viroid
R. Mycoplasma
S. Rickettsia
List II: (Key Feature)
1. Lacks a cell wall
2. Infectious protein
3. Obligate intracellular bacterial parasite
4. Infectious RNA
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

11. What is the genetic material of the Tobacco Mosaic Virus (TMV)?
(A) Double-stranded DNA
(B) Single-stranded DNA
(C) Double-stranded RNA
(D) Single-stranded RNA

12. The ultra-structure of a T-even bacteriophage is best described as:
(A) A spherical shape featuring prominent surface spikes.
(B) A complex structure with an icosahedral head and a tail.
(C) A rod-shaped structure with a helical symmetry pattern.
(D) A filamentous form that is characterized as being flexible.

13. Consider the following statements about plasmids:
1. They are extrachromosomal, circular DNA molecules.
2. They replicate independently of the host chromosome.
3. They are essential for the survival of the bacterial cell under normal conditions.
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

14. Which group of microorganisms are known for producing many of the antibiotics used in medicine?
(A) Mycoplasma
(B) Rickettsia
(C) Prions
(D) Actinomycetes

15. Virusoids are best described as:
(A) Circular ssRNA molecules requiring a helper virus.
(B) Infectious proteins causing neurological diseases.
(C) Small bacteria lacking a functional cell wall.
(D) Viruses that infect and destroy various fungi.

16. A plant exhibits symptoms of yellowing, mottling, and leaf curl. These are most characteristic of an infection by which type of pathogen?
(A) Fungus
(B) Virus
(C) Alga
(D) Mycoplasma

17. Which of the following characteristics distinguishes Archaebacteria from Eubacteria?
(A) Presence of a nucleus
(B) Presence of ether-linked lipids in the cell membrane
(C) Presence of peptidoglycan in the cell wall
(D) Ability to perform photosynthesis

18. Arrange the following steps of a lytic viral replication cycle in the correct chronological order:
1. Assembly
2. Penetration
3. Attachment
4. Release
5. Synthesis
(A) 3, 2, 5, 1, 4
(B) 2, 3, 5, 1, 4
(C) 3, 5, 2, 1, 4
(D) 1, 2, 3, 4, 5

19. Identify the incorrect statement.
(A) TMV - Helical symmetry

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(B) Bacteriophage - Tadpole shape
(C) Prion - Nucleic acid core
(D) Adenovirus - Icosahedral symmetry

20. Organisms belonging to the group Chlamydia are characterized as:
(A) Gram-positive bacteria that form endospores.
(B) Free-living nitrogen-fixing bacteria.
(C) Photosynthetic cyanobacteria.
(D) Obligate intracellular energy parasites.

21. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Mycoplasmas are resistant to penicillin.
Reason (R): Penicillin acts by inhibiting cell wall synthesis, and mycoplasmas lack a cell wall.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

22. The process of viral replication where the viral genome integrates into the host's chromosome and is replicated along with it is known as the:
(A) Lytic cycle
(B) Lysogenic cycle
(C) Endocytic pathway
(D) Exocytic pathway

23. Which term refers to the protein subunit that makes up the viral capsid?
(A) Virion
(B) Peplomer
(C) Nucleoid
(D) Capsomere

24. What is the primary mode of nutrition for most bacteria?
(A) Heterotrophic (saprophytic or parasitic)
(B) Photosynthesis
(C) Chemosynthesis
(D) Holozoic

25. The ultra-structure of a typical eubacterial cell includes all of the following EXCEPT:
(A) A cell wall containing peptidoglycan.
(B) Ribosomes for protein synthesis.
(C) A well-defined nucleus with a membrane.
(D) A single circular chromosome in a nucleoid.

26. Which of the following statements about Cyanobacteria is incorrect?
(A) They possess chloroplasts for photosynthesis.
(B) They are prokaryotic organisms.
(C) They perform oxygenic photosynthesis similar to plants.
(D) Some species can fix atmospheric nitrogen.

27. The economic importance of bacteria includes which of the following processes?
(A) Causing all known plant diseases and producing mycotoxins.
(B) Forming the basis of all marine food chains through chemosynthesis.
(C) Exclusively causing spoilage of all food types.
(D) Antibiotic production, dairy fermentation, and nitrogen fixation.

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28. Consider the following statements regarding bacterial reproduction:
1. Binary fission is the most common method of asexual reproduction.
2. Sexual reproduction involving meiosis and zygote formation is common.
3. Genetic recombination can occur through transformation, transduction, and conjugation.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

29. A bacterium that obtains energy from oxidizing inorganic compounds like ammonia or sulfur is best described as a:
(A) Photoautotroph
(B) Photoheterotroph
(C) Chemoautotroph
(D) Chemoheterotroph

30. The specialized cells in certain Cyanobacteria that are the site of nitrogen fixation are called:
(A) Hormogonia

(B) Akinetes
(C) Endospores
(D) Heterocysts

31. Match List I with List II regarding bacterial structures and their functions:
List I: (Structure)
P. Flagellum
Q. Pilus
R. Capsule
S. Ribosome
List II: (Function)
1. Protein synthesis
2. Attachment and conjugation
3. Motility
4. Protection from phagocytosis
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-1, R-3, S-2

32. What is a defining characteristic of fungi?
(A) They are prokaryotic.
(B) They are absorptive heterotrophs.
(C) They have cell walls made of peptidoglycan.
(D) They contain chlorophyll for photosynthesis.

33. Consider the following statements:
Statement I: The cell wall of most fungi is primarily composed of chitin.
Statement II: The cell wall of oomycetes (a group in Mastigomycotina) is primarily composed of cellulose.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

34. A fungus is observed to have coenocytic (aseptate) hyphae and produces zygospores as the result of sexual reproduction. It most likely belongs to which group?
(A) Zygomycotina
(B) Ascomycotina
(C) Basidiomycotina
(D) Deuteromycotina

35. The phenomenon where two genetically different nuclei coexist and divide within the same fungal hypha is known as:
(A) Heterothallism
(B) Parasexuality
(C) Heterokaryosis
(D) Homothallism

36. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Deuteromycotina is often referred to as "Fungi Imperfecti".
Reason (R): This group includes fungi in which the sexual stage of reproduction has not been observed.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

37. The characteristic sexual spore produced by members of the Ascomycotina is the:
(A) Zygospore
(B) Basidiospore
(C) Ascospore
(D) Oospore

38. Mycorrhiza represents a symbiotic relationship between:
(A) A fungus and an alga.
(B) A fungus and the roots of a higher plant.
(C) A fungus and a bacterium.
(D) A virus and a fungus.

39. A patient is diagnosed with a fungal infection of the skin. Aflatoxin contamination in food is unlikely to be the cause because aflatoxins are:
(A) A type of fungal spore rather than a chemical.
(B) Beneficial organic compounds produced by fungi.
(C) A common type of ubiquitous airborne allergen.
(D) Toxic mycotoxins produced by molds on crops.

40. Identify the incorrect statement regarding the general characteristics of fungi.
(A) All fungi are multicellular.
(B) Fungi are eukaryotic organisms.

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(C) Fungi store food as glycogen.
(D) Fungi reproduce by means of spores.

41. The parasexual cycle in fungi provides a mechanism for genetic recombination without involving:
(A) Mitosis and cytokinesis.
(B) Hyphal fusion and plasmogamy.
(C) Meiotic division and sexual structures.
(D) Karyogamy and nuclear fusion.

42. Which of the following fungal groups is characterized by the production of motile zoospores with flagella?
(A) Mastigomycotina
(B) Zygomycotina
(C) Ascomycotina
(D) Deuteromycotina

43. A plant disease characterized by white, powdery patches on leaves, caused by a fungus like Erysiphe, is a classic example of a host-parasite relationship where the parasite is:
(A) An obligate saprophyte
(B) An endoparasite
(C) A facultative saprophyte
(D) An ectoparasite

44. Consider the following statements about lichens:
1. They are a single organism, a type of fungus.
2. They represent a symbiotic association between a mycobiont and a phycobiont.
3. The fungal partner is typically an Ascomycete.

Which of the statements given above is/are correct?
(A) 1 only
(B) 2 only
(C) 2 and 3 only
(D) 1 and 3 only

45. Clamp connections are a characteristic feature found in the hyphae of which fungal group, ensuring that sister nuclei are separated during cell division?
(A) Zygomycotina
(B) Ascomycotina
(C) Basidiomycotina
(D) Deuteromycotina

46. Which of the following is an example of an economically important fungus used in baking and brewing industries?
(A) Aspergillus niger
(B) Penicillium notatum
(C) Rhizopus stolonifer
(D) Saccharomyces cerevisiae

47. The term "heterothallism" in fungi refers to:
(A) The requirement of two compatible mating types for sexual reproduction.
(B) The production of two different types of spores.
(C) The existence of a diploid and a haploid phase in the life cycle.
(D) The ability to grow on a wide variety of substrates.

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48. A farmer notices that his corn crop is contaminated with a mold that produces toxins harmful to livestock. This is a problem related to:
(A) Mycorrhizae
(B) Mycotoxins
(C) Algal blooms
(D) Bacteriophages

49. Which of the following is a general characteristic used for the classification of algae?
(A) Presence or absence of a nucleus.
(B) Type of photosynthetic pigments and reserve food material.
(C) Composition of the cell wall (peptidoglycan vs. chitin).
(D) Mode of nutrition (autotrophic vs. heterotrophic).

50. The thallus organization in algae can range from unicellular to complex multicellular forms. A colonial form of thallus is exemplified by:
(A) Volvox
(B) Chlamydomonas
(C) Ulva
(D) Laminaria

51. Match List I with List II regarding algal divisions and their primary characteristics:
List I: (Algal Division)
P. Chlorophyta
Q. Phaeophyta
R. Rhodophyta

S. Bacillariophyta

List II: (Primary Characteristic)

1. Fucoxanthin pigment, Laminarin storage
2. Phycobilin pigments, Floridean starch
3. Silica frustules, Chrysolaminarin storage
4. Chlorophyll a and b, Starch storage

(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-3, S-1

52. The phenomenon of "algal blooms" is often detrimental to aquatic ecosystems primarily because:
(A) The algae produce excess oxygen, which is toxic to fish.
(B) The algae physically clog the gills of fish.
(C) The algae increase the water temperature to lethal levels.
(D) Bacterial decomposition of dead algae depletes oxygen.

53. Which algal group is characterized by the complete absence of flagellated stages in its life cycle?
(A) Chlorophyta (Green algae)
(B) Phaeophyta (Brown algae)
(C) Rhodophyta (Red algae)
(D) Xanthophyta (Yellow-green algae)

54. The economic importance of algae includes the production of agar, which is extracted from:
(A) Brown algae like Laminaria.
(B) Red algae like Gelidium and Gracilaria.
(C) Green algae like Chlorella.
(D) Diatoms.

55. Prochlorophyta are a unique group of algae because they possess:
(A) Chlorophyll a and phycobilins, similar to red algae.
(B) Chlorophyll a and fucoxanthin, similar to brown algae.
(C) Only chlorophyll c and are eukaryotic in nature.
(D) Chlorophyll a and b, but are strictly prokaryotic.

56. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Diatoms (Bacillariophyta) are of great economic importance as diatomaceous earth.
Reason (R): The cell walls of diatoms are impregnated with indestructible silica, which accumulates in massive deposits over geological time.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

57. The main reserve food material in Phaeophyta (brown algae) is:
(A) Starch
(B) Floridean starch
(C) Laminarin and mannitol
(D) Chrysolaminarin

58. Identify the correct statement about Charophyta.
(A) They are considered the closest living relatives of land plants.
(B) They are simple, unicellular, and planktonic algae.
(C) They lack chlorophyll and are heterotrophic.
(D) They reproduce exclusively by asexual means.

59. A student observing a water sample under a microscope finds unicellular organisms with two unequal flagella and a yellowish-green color. They store food as oil. This organism likely belongs to:
(A) Chlorophyta
(B) Rhodophyta
(C) Phaeophyta
(D) Xanthophyta

60. The complex reproductive structures, including the carpogonium and antheridium, and post-fertilization developments leading to the carposporophyte are characteristic of which algal group?
(A) Chlorophyta
(B) Rhodophyta
(C) Phaeophyta
(D) Bacillariophyta

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61. Which of the following is NOT a characteristic of viruses?
(A) They are filterable.
(B) They can be crystallized.
(C) They can grow on artificial nutrient media.
(D) They are obligate parasites.

62. In the context of a bacteriophage's lytic cycle, what is the 'eclipse period'?
(A) The phase where no infective virions are detectable.
(B) The time when the phage attaches to the host cell.
(C) The time it takes for the host cell to lyse.
(D) The phase where the phage DNA integrates into the host genome.

63. Consider the following statements about Rickettsia and Chlamydia:
1. Both are obligate intracellular parasites.
2. Both are considered bacteria, not viruses.
3. Both are transmitted primarily through the fecal-oral route.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

64. What is the fundamental difference between a virion and a viroid?
(A) A virion contains DNA, while a viroid contains RNA.
(B) A virion infects plants, while a viroid infects animals.
(C) A virion has a protein coat, while a viroid does not.
(D) A virion is a complete virus particle, while a viroid is a bacterial plasmid.

65. A scientist discovers a new microbe in a high-salt environment like the Dead Sea. Based on its habitat, it is most likely a(n):
(A) Methanogen
(B) Extreme halophile
(C) Thermoacidophile
(D) Cyanobacterium

66. Arrange the following events in the chronological order of the parasexual cycle in fungi:
1. Mitotic recombination
2. Haploidization
3. Formation of a diploid nucleus
4. Plasmogamy
5. Karyogamy

(A) 4, 5, 3, 1, 2
(B) 4, 5, 1, 3, 2
(C) 4, 3, 5, 2, 1
(D) 1, 2, 3, 4, 5

67. Which term describes bacteria that are rod-shaped?
(A) Bacilli
(B) Cocci
(C) Spirilla
(D) Vibrio

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68. Identify the correct pair of a fungal disease and its common name.
(A) Puccinia graminis - Smut of wheat
(B) Ustilago tritici - Rust of wheat
(C) Phytophthora infestans - Late blight of potato
(D) Albugo candida - Powdery mildew

69. The phycobiont in a lichen performs which essential function for the symbiotic partnership?
(A) Performs photosynthesis to produce carbohydrates.
(B) Provides structural support and protection.
(C) Absorbs water and minerals from the substrate.
(D) Fixes atmospheric nitrogen.

70. Consider the following statements:
Statement I: In brown algae, the plant body is typically differentiated into a holdfast, stipe, and frond.
Statement II: Red algae show a similar level of differentiation with true roots, stems, and leaves.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

71. Fucoxanthin is a characteristic brownish pigment found in:
(A) Rhodophyta and Cyanobacteria
(B) Phaeophyta and Bacillariophyta
(C) Chlorophyta and Charophyta

(D) Xanthophyta and Prochlorophyta

72. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Many species of Cyanobacteria can survive in harsh environmental conditions.
Reason (R): They can form thick-walled resting spores called akinetes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

73. The cell wall of diatoms, known as a frustule, is composed of two overlapping halves. This structure is primarily made of:
(A) Chitin
(B) Cellulose
(C) Peptidoglycan
(D) Silica

74. A mushroom, which has a fruiting body with gills that produce basidiospores, belongs to the group:
(A) Zygomycotina
(B) Ascomycotina
(C) Deuteromycotina
(D) Basidiomycotina

75. What is the most appropriate description of the nutritional mode of fungi?
(A) Absorptive chemoheterotrophic
(B) Photoautotrophic
(C) Chemoautotrophic
(D) Ingestive chemoheterotrophic

76. Match List I with List II concerning different forms of genetic recombination in bacteria:
List I: (Process)
P. Transformation
Q. Conjugation
R. Transduction
S. Binary Fission
List II: (Description)
1. Gene transfer via a bacteriophage
2. Uptake of naked DNA from the environment
3. Asexual cell division
4. Gene transfer through a pilus (cell-to-cell contact)
(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-1, R-4, S-3

77. Which of the following is NOT a viral disease?
(A) Tobacco mosaic
(B) Influenza
(C) Polio
(D) Tuberculosis

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78. The term 'mycobiont' refers to:
(A) The fungal partner in a lichen.
(B) The algal partner in a lichen.
(C) The root partner in a mycorrhiza.
(D) A disease-causing fungus.

79. Which of the following algal groups includes members that are predominantly marine and grow at great depths?
(A) Chlorophyta
(B) Charophyta
(C) Rhodophyta
(D) Xanthophyta

80. Identify the incorrect statement about the economic importance of fungi.
(A) All mycorrhizal associations are pathogenic to plants.
(B) Penicillium is a source of antibiotics.
(C) Saccharomyces is used in fermentation.
(D) Some mushrooms like Agaricus are edible.

81. A virologist is studying an agent that is essentially a circular ssRNA molecule encapsidated in the coat protein of a different, helper virus. This agent is a:
(A) Viroid
(B) Prion
(C) Virusoid
(D) Plasmid

82. In fungi, plasmogamy is the fusion of:
(A) Nuclei
(B) Cytoplasm
(C) Spores
(D) Gametes of the same mating type

83. The unique prokaryotic group Prochlorophyta is significant in evolutionary studies because its members:
(A) Lack a cell wall, similar to mycoplasmas.
(B) Are the only prokaryotes capable of nitrogen fixation.
(C) Contain chlorophylls a and b, similar to land plants.
(D) Have a true nucleus but lack other organelles.

84. Consider the following statements regarding the control of viral diseases:
1. Antibiotics are highly effective in treating viral infections.
2. Vaccination works by stimulating the host's immune system to recognize the virus.
3. Antiviral drugs often work by inhibiting viral replication enzymes.

Which of the statements given above is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 2 only
(D) 1, 2 and 3

85. Which of the following is a key difference between Archaebacteria and Eubacteria?
(A) Archaebacteria have ether-linked lipids in their cell membranes.
(B) Archaebacteria have a nucleus, while Eubacteria do not.
(C) Eubacteria have cell walls of chitin, while Archaebacteria do not.
(D) Eubacteria are all pathogenic, while Archaebacteria are not.

86. A lichen showing a leafy, flattened thallus that is loosely attached to the substrate is classified as:
(A) Crustose
(B) Foliose
(C) Fruticose
(D) Squamulose

87. Which of the following is an example of a disease caused by a prion?
(A) AIDS
(B) Influenza
(C) Kuru
(D) Tuberculosis

88. The main reserve food material in members of Chlorophyta is:
(A) Laminarin
(B) Mannitol
(C) Floridean starch
(D) Starch

89. A student isolates a fungus that has septate hyphae and produces asexual spores called conidia, but no sexual stage is observed. The student should tentatively place this fungus in:
(A) Mastigomycotina
(B) Zygomycotina
(C) Deuteromycotina
(D) Basidiomycotina

90. The host-parasite relationship in a disease like wheat rust is complex. The fungus Puccinia graminis is an obligate parasite, meaning it:
(A) Can only grow and reproduce on a living host.
(B) Can grow on either a living host or dead organic matter.
(C) Kills the host immediately upon infection.
(D) Forms a mutually beneficial relationship with the host.

91. Which of the following is a characteristic of TMV ultra-structure?
(A) An icosahedral head with a contractile tail.
(B) A flexible filamentous shape.
(C) A spherical envelope with glycoprotein spikes.
(D) A rigid rod-like structure with helical capsomeres.

92. The process of transferring genetic material from one bacterium to another via a bacteriophage is called:
(A) Transformation
(B) Transduction
(C) Conjugation
(D) Translation

93. Consider the following statements:
Statement I: Actinomycetes are true bacteria, although they exhibit fungus-like filamentous growth.
Statement II: Like fungi, the cell walls of Actinomycetes are composed of chitin.
Which of the above statements is/are correct?

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(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

94. The fruiting body of an ascomycete fungus, such as a cup fungus, is called an:
(A) Ascogonium
(B) Ascospore
(C) Ascus
(D) Ascocarp

95. In phycology, which criterion is NOT typically used for the major classification of algae?
(A) Presence or absence of mitochondria
(B) Thallus organization
(C) Types of pigments
(D) Nature of reserve food

96. Arrange the following algal groups based on the increasing complexity of their typical thallus organization (from simple to complex):
1. Phaeophyta
2. Chlorophyta (unicellular forms)
3. Charophyta
4. Chlorophyta (colonial forms)

(A) 2, 4, 3, 1
(B) 2, 3, 4, 1
(C) 1, 3, 4, 2
(D) 4, 2, 1, 3

97. An organism is described as prokaryotic, photosynthetic, containing chlorophyll a and phycobilins, and capable of nitrogen fixation. This organism is a:
(A) Green alga
(B) Brown alga
(C) Cyanobacterium
(D) Diatom

98. A mycotoxin is a:
(A) Toxin that specifically targets fungi.
(B) Toxin produced by a fungus.
(C) Type of antibiotic derived from a fungus.
(D) Structural component of the fungal cell wall.

99. The "Red Tides" that can cause massive fish kills and human illness are typically caused by blooms of:
(A) Cyanobacteria
(B) Diatoms
(C) Dinoflagellates
(D) Green algae

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100. Identify the incorrect pair regarding algal groups and their characteristics.
(A) Rhodophyta - Non-motile cells
(B) Phaeophyta - Starch as reserve food
(C) Bacillariophyta - Silica cell wall
(D) Chlorophyta - Chlorophylls a and b

101. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Viroids are capable of causing disease in plants.
Reason (R): They are small, circular RNA molecules that interfere with the host's normal gene expression and metabolic processes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

102. Which of the following best describes the ultra-structure of a mycoplasma?
(A) A typical prokaryotic cell with a thick peptidoglycan wall.
(B) A eukaryotic cell lacking mitochondria.
(C) A cell-like structure containing only RNA and a protein coat.
(D) A wall-less prokaryote bounded by a plasma membrane.

103. In the life cycle of a fungus like Rhizopus (Zygomycotina), the thick-walled resting spore formed from the fusion of two gametangia is the:
(A) Oospore
(B) Zygospore
(C) Ascospore
(D) Basidiospore

104. Match List I with List II regarding fungal reproduction and genetics:
List I: (Term)
P. Heterokaryosis
Q. Heterothallism

R. Parasexuality
S. Homothallism

List II: (Definition)
1. Sexual recombination without meiosis
2. Two different nuclei in the same cytoplasm
3. Self-fertile; can reproduce sexually on its own
4. Requires two compatible partners for sexual reproduction

(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-4, Q-1, R-2, S-3

105. A researcher is studying a plant disease that causes downy mildew on grapes. The causative agent would most likely belong to which fungal group?
(A) Ascomycotina
(B) Basidiomycotina
(C) Mastigomycotina
(D) Deuteromycotina

106. Which of the following is a unicellular alga widely used in research and as a potential food source?
(A) Laminaria
(B) Fucus
(C) Sargassum
(D) Chlorella

107. The presence of phycobilisomes containing phycoerythrin and phycocyanin is a distinguishing feature of which two groups?
(A) Rhodophyta and Cyanobacteria
(B) Chlorophyta and Charophyta
(C) Phaeophyta and Bacillariophyta
(D) Xanthophyta and Prochlorophyta

108. Consider the following statements:
1. All bacteria are harmful and cause diseases.
2. Archaebacteria are known to inhabit extreme environments.
3. Cyanobacteria release oxygen as a byproduct of photosynthesis.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

109. What is the role of reverse transcriptase in the replication of a retrovirus?
(A) It translates viral RNA into proteins.
(B) It cuts the host cell's DNA to insert the viral genome.
(C) It builds a DNA copy from the viral RNA template.
(D) It assembles new infectious viral particles.

110. A filamentous, unbranched thallus is a common organizational form in which algal group?
(A) Spirogyra
(B) Volvox
(C) Chlamydomonas
(D) Laminaria

111. All of the following are components of a typical T-even bacteriophage structure EXCEPT:
(A) A capsid head containing DNA.
(B) A contractile sheath.
(C) Tail fibers for attachment.
(D) A lipid envelope derived from the host.

112. The biological importance of Cyanobacteria stems from their role as:
(A) Primary decomposers in terrestrial ecosystems.
(B) Pioneer oxygenic photosynthesizers and nitrogen fixers.
(C) Pathogens causing major human epidemics.
(D) Producers of commercially valuable antibiotics.

113. Consider the following statements:
Statement I: The fruiting body of a mushroom is a basidiocarp.
Statement II: The basidiocarp is composed of dikaryotic hyphae.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

114. How are prions different from all other known infectious agents?
(A) They are composed of RNA without a protein coat.
(B) They contain both DNA and RNA.
(C) They can replicate outside of a host cell.
(D) They appear to lack any nucleic acid (DNA

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or RNA).

115. A key step in the diagnosis of many bacterial infections is the Gram stain, which differentiates bacteria based on the composition of their:
(A) Cell wall
(B) Cell membrane
(C) Ribosomes
(D) Flagella

116. Which of the following algal groups is characterized by having starch as a reserve food material and chlorophylls a and b as major pigments?
(A) Phaeophyta
(B) Chlorophyta
(C) Rhodophyta
(D) Bacillariophyta

117. The symbiotic association in mycorrhiza is generally considered mutualistic because:
(A) The fungus protects the plant from viruses.
(B) Both partners exchange essential nutrients and water.
(C) The plant provides the fungus with shelter.
(D) The fungus fixes atmospheric nitrogen for the plant.

118. Which statement correctly describes the cellular organization of fungi?
(A) Fungi are eukaryotic, and can be unicellular (yeasts) or multicellular (molds).
(B) All fungi are prokaryotic and unicellular.
(C) All fungi are eukaryotic and multicellular.
(D) Fungi are prokaryotic, and can be unicellular or filamentous.

119. A plant pathologist observes a smut disease in wheat crops. The pathogen responsible for this disease belongs to the class:
(A) Ascomycetes
(B) Zygomycetes
(C) Basidiomycetes
(D) Oomycetes

120. In algae, flagellation patterns are an important taxonomic criterion. Heterokont flagellation refers to:
(A) Two identical, smooth flagella.
(B) A single polar flagellum.
(C) The complete absence of flagella.
(D) Two dissimilar flagella, one tinsel and one whiplash.

121. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Lichens are sensitive to air pollution, especially sulfur dioxide.
Reason (R): They efficiently absorb minerals and water directly from the atmosphere, including pollutants, which can be toxic.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

122. What is the principal role of a plasmid in a bacterial cell?
(A) It forms the primary chromosome of the bacterium.
(B) It often carries genes for antibiotic resistance or other special functions.
(C) It carries genes for essential metabolic pathways like glycolysis.
(D) It is the site of protein synthesis.

123. The group Xanthophyta is also known as yellow-green algae because:
(A) They lack chlorophyll a and have only carotenoids.
(B) They possess chlorophyll a and c, but lack fucoxanthin.
(C) Their chlorophylls are masked by an abundance of xanthophyll pigments.
(D) They are genetically identical to green algae but appear yellow in certain light.

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124. Consider the following characteristics:
1. Eukaryotic
2. Cell wall made of chitin
3. Absorptive heterotroph
4. Stores food as glycogen
Which of the following kingdoms is defined by these features?
(A) Plantae
(B) Animalia
(C) Fungi
(D) Monera

125. Which of the following is NOT a form of asexual reproduction in fungi?
(A) Plasmogamy
(B) Budding
(C) Fragmentation
(D) Formation of conidia

126. Match List I with List II regarding algal products and their source groups:
List I: (Product)
P. Agar
Q. Alginic acid
R. Carrageenan
S. Diatomaceous earth
List II: (Source Group)
1. Phaeophyta
2. Bacillariophyta
3. Rhodophyta (e.g., Chondrus)
4. Rhodophyta (e.g., Gelidium)
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

127. The most advanced and complex thallus structure among the given algal groups is found in:
(A) Xanthophyta
(B) Phaeophyta
(C) Chlorophyta
(D) Prochlorophyta

128. A virus that infects a bacterium is known as a(n):
(A) Viroid
(B) Prion
(C) Bacteriophage
(D) Mycoplasma

129. Which of the following is a key biological role of Cyanobacteria?
(A) Causing neurodegenerative diseases in mammals.
(B) Decomposing complex organic matter in soil.
(C) Producing potent antiviral medications.
(D) Contributing to aquatic production and atmospheric oxygen.

130. A scientist analyzing the cell wall of an unknown organism finds that it is composed primarily of pseudo-peptidoglycan. This organism is most likely a(n):
(A) Archaebacterium
(B) Eubacterium
(C) Fungus
(D) Alga

131. The "ascus" in Ascomycotina is a sac-like structure that typically contains:
(A) A single diploid zygote.
(B) Eight haploid ascospores.
(C) Four basidiospores.
(D) Numerous conidiospores.

132. A particular plant disease symptom involves the replacement of the host's ovaries with a black, powdery mass of fungal spores. This disease is a:
(A) Rust
(B) Downy mildew
(C) Smut
(D) Powdery mildew

133. Consider the following statements:
Statement I: All algae are photosynthetic.
Statement II: Some algae are secondarily heterotrophic, having lost their photosynthetic pigments.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

134. Which of the following is an example of a viral disease in humans?
(A) Tetanus
(B) Cholera
(C) Malaria
(D) Measles

135. The main function of heterocysts in cyanobacteria is:
(A) Nitrogen fixation
(B) Photosynthesis
(C) Perennation
(D) Buoyancy

136. Consider the following statements about fungal nutrition:
1. Saprophytic fungi obtain nutrients from dead organic matter.

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2. Parasitic fungi absorb nutrients from living hosts.
3. Symbiotic fungi live in a mutually beneficial relationship with another organism.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

137. Floridean starch is the characteristic reserve food material of:
(A) Phaeophyta
(B) Rhodophyta
(C) Chlorophyta
(D) Bacillariophyta

138. The mode of reproduction in bacteria that involves the direct transfer of genetic material between two cells in contact is:
(A) Transformation
(B) Transduction
(C) Conjugation
(D) Binary fission

139. A fungus that produces zoospores for asexual reproduction most likely belongs to:
(A) Zygomycotina
(B) Ascomycotina
(C) Basidiomycotina
(D) Mastigomycotina

140. Arrange the following taxonomic ranks in the correct descending order:
1. Division
2. Class
3. Order
4. Family

(A) 1, 2, 3, 4
(B) 4, 3, 2, 1
(C) 1, 3, 2, 4
(D) 2, 1, 3, 4

141. What structural feature of mycoplasmas allows them to pass through filters that retain bacteria?
(A) Their rigid, crystalline cell wall.
(B) Their lack of a wall and pleomorphic nature.
(C) Their extremely small ribosomes.
(D) Their ability to form endospores.

142. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Parasexuality in fungi is a significant source of genetic variation.
Reason (R): It involves mitotic crossing-over and subsequent haploidization, which re-assorts genes on different chromosomes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

143. Which of the following is a primary criterion used to classify fungi into major divisions like Ascomycotina and Basidiomycotina?
(A) The type of asexual spores produced.
(B) Their nutritional mode (saprophytic vs. parasitic).
(C) The chemical composition of their reserve food.
(D) The nature of their sexual reproductive structures and spores.

144. In the context of a host-parasite relationship, a 'facultative parasite' is an organism that:
(A) Normally acts as a saprophyte but can infect hosts.
(B) Can only survive on a living host.
(C) Is normally parasitic but can survive as a saprophyte.
(D) Lives symbiotically with its host without causing disease.

145. The pigments phycoerythrin and phycocyanin, characteristic of red algae and cyanobacteria, are collectively known as:
(A) Carotenoids
(B) Phycobilins
(C) Chlorophylls
(D) Xanthophylls

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146. A patient is suffering from a disease caused by an organism from the genus Rickettsia. Which of the following is most likely the mode of transmission?
(A) Ingestion of contaminated food.
(B) Inhalation of airborne droplets.

(C) A bite from an arthropod vector like a tick.
(D) Direct skin contact with an infected individual.

147. Which of the following statements about Charophyta is incorrect?
(A) They exhibit a high degree of thallus differentiation.
(B) They are considered evolutionary precursors to land plants.
(C) Oogamy is a common mode of sexual reproduction.
(D) They are all marine, deep-water algae.

148. A lichen thallus that is shrub-like and branched, attached to the substrate at a single point, is described as:
(A) Fruticose
(B) Crustose
(C) Foliose
(D) Leprose

149. Identify the correct statement regarding viral replication.
(A) Viruses can replicate independently using their own ribosomes.
(B) All viruses replicate their genome in the host cell's nucleus.
(C) Viral replication is dependent on the host cell's metabolic machinery.
(D) Viral replication always results in the immediate lysis of the host cell.

150. Match List I with List II regarding fungal groups and their characteristic features:
List I: (Fungal Group)
P. Mastigomycotina
Q. Zygomycotina
R. Ascomycotina
S. Basidiomycotina
List II: (Characteristic Feature)
1. Ascus with ascospores
2. Basidium with basidiospores
3. Motile zoospores
4. Aseptate hyphae, zygospores
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

151. Which of these microorganisms is prokaryotic?
(A) Yeast (Saccharomyces)
(B) Escherichia coli
(C) Amoeba
(D) Chlamydomonas

152. A dikaryotic phase (n+n) is a prominent feature in the life cycle of which two fungal groups?
(A) Zygomycotina and Deuteromycotina
(B) Mastigomycotina and Zygomycotina
(C) Ascomycotina and Basidiomycotina
(D) Mastigomycotina and Ascomycotina

153. A virus with an icosahedral capsid has a shape that is roughly:
(A) Rod-like
(B) Filamentous
(C) Complex with a head and tail
(D) Spherical or polyhedral

154. What is a "prophage"?
(A) Viral DNA integrated into a bacterial chromosome.
(B) A virus that has not yet infected a host cell.
(C) The protein coat of a virus.
(D) An incomplete virus particle lacking nucleic acid.

155. Which of the following describes the thallus of Ulva?
(A) Unicellular and motile
(B) Parenchymatous and sheet-like
(C) Filamentous and unbranched
(D) Colonial and spherical

156. Consider the following statements about viroids:
1. They are composed of protein only.
2. They are infectious agents of plants.
3. They have a smaller genome than viruses.
Which of the statements given above is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 2 only
(D) 1, 2 and 3

157. The "Fungi Imperfecti" or Deuteromycotina are so-named because:
(A) They are imperfectly understood and cannot be cultured.
(B) They lack a definite cell wall.
(C) They are all obligate parasites and cannot

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live independently.
(D) Their sexual stage of reproduction is unknown or absent.

158. Consider the following statements:
Statement I: Alginates extracted from brown algae are used as thickeners and emulsifiers in the food industry.
Statement II: Agar extracted from red algae is used to make culture media for microbes.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

159. The causative agent of potato spindle tuber disease is a:
(A) Viroid
(B) Virus
(C) Bacterium
(D) Fungus

160. From a biological standpoint, what is the primary significance of sexual reproduction in fungi?
(A) It allows for rapid population growth.
(B) It creates genetic variation through recombination.
(C) It is the only way for fungi to produce spores.
(D) It produces diploid individuals that are more resistant to environmental stress.

161. Which of the following is NOT a general characteristic of the kingdom Fungi?
(A) Eukaryotic cells
(B) Presence of chlorophyll
(C) Heterotrophic nutrition
(D) Cell walls containing chitin

162. A bacterial cell takes up a piece of naked DNA from its environment and incorporates it into its own chromosome. This process is known as:
(A) Transformation
(B) Conjugation
(C) Transduction
(D) Transcription

163. The pigment composition of Rhodophyta (red algae), with chlorophyll a, d, and phycobilins, allows them to:
(A) Tolerate extremely high temperatures.
(B) Absorb blue-green light that penetrates to deeper water.
(C) Survive for long periods out of water.
(D) Fix atmospheric nitrogen more efficiently than other algae.

164. Arrange the following steps of the lysogenic cycle in the correct sequence after viral entry:
1. Prophage is copied during bacterial cell division.
2. Viral DNA integrates into the host chromosome.
3. Induction occurs, and the prophage excises.
4. The host cell lives and reproduces normally.
(A) 2, 4, 1, 3
(B) 1, 2, 3, 4
(C) 2, 3, 1, 4
(D) 4, 1, 2, 3

165. The reserve food in diatoms (Bacillariophyta) is stored as:
(A) Starch
(B) Glycogen
(C) Chrysolaminarin and oils
(D) Laminarin

166. Which structure is analogous in function to the capsid of a virus?
(A) The cell membrane of a bacterium.
(B) The protein shell enclosing the nucleic acid.
(C) The nucleus of a eukaryotic cell.
(D) The cell wall of a plant cell.

167. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Endomycorrhizae, specifically arbuscular mycorrhizae, are extremely common in nature.
Reason (R): The fungal hyphae penetrate the cortical cells of the plant roots to form highly branched structures called arbuscules, facilitating nutrient exchange.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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168. You are given a microorganism that is prokaryotic, lacks peptidoglycan in its cell wall, and lives in a hot sulfur spring. It belongs to the domain:
(A) Archaea
(B) Bacteria
(C) Eukarya
(D) Fungi

169. What is the fundamental difference between a plasmid and the bacterial chromosome?
(A) Plasmids are made of RNA, while chromosomes are made of DNA.
(B) Plasmids are linear, while chromosomes are circular.
(C) Chromosomes carry essential genes, while plasmids carry non-essential genes.
(D) Chromosomes are found in the nucleoid, while plasmids are in the cytoplasm.

170. "Akinetes" and "Hormogonia" are structures associated with reproduction and perennation in:
(A) Cyanobacteria
(B) Fungi
(C) Viruses
(D) Mycoplasma

171. A scientist has isolated a fungus whose hyphae are coenocytic (aseptate) and which forms motile zoospores. This fungus belongs to:
(A) Zygomycotina
(B) Ascomycotina
(C) Mastigomycotina
(D) Deuteromycotina

172. The relationship between the fungus and the alga in a lichen is best described as:
(A) Parasitism
(B) Mutualistic symbiosis
(C) Commensalism
(D) Predation

173. Which of the following best describes the habitat of Phaeophyta (brown algae)?
(A) Mostly freshwater, warm environments.
(B) Predominantly terrestrial, in moist soil.
(C) Predominantly marine, in cool coastal waters.
(D) Mostly symbiotic within corals.

174. Identify the correct pair.
(A) Chlorophyta - Fucoxanthin
(B) Phaeophyta - Phycocyanin
(C) Bacillariophyta - Chlorophyll b
(D) Rhodophyta - Phycoerythrin

175. The term 'virion' refers to:
(A) A complete, infectious virus particle outside a host cell.
(B) The nucleic acid of a virus.
(C) A misfolded infectious protein.
(D) The provirus stage in the lysogenic cycle.

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176. Match List I with List II regarding pathogens and diseases:
List I: (Pathogen)
P. Phytophthora infestans
Q. Puccinia graminis tritici
R. Ustilago tritici
S. Tobacco Mosaic Virus
List II: (Disease)
1. Black stem rust of wheat
2. Loose smut of wheat
3. Tobacco mosaic disease
4. Late blight of potato
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

177. Which of the following characteristics is shared by both Archaebacteria and Eubacteria?
(A) Presence of peptidoglycan in the cell wall.
(B) Prokaryotic cellular organization.
(C) Presence of a membrane-bound nucleus.
(D) Ether-linked membrane lipids.

178. Dolipore septa are a characteristic feature of the hyphae in which group of fungi?
(A) Ascomycotina
(B) Zygomycotina
(C) Basidiomycotina
(D) Deuteromycotina

179. A researcher identifies a new organism with chlorophylls a and b, starch as a storage product, and a cell wall of cellulose. However, it is prokaryotic. This organism would be classified under:
(A) Chlorophyta
(B) Cyanobacteria

(C) Charophyta
(D) Prochlorophyta

180. Aflatoxins, potent carcinogens, are mycotoxins produced by certain species of:
(A) Aspergillus
(B) Penicillium
(C) Saccharomyces
(D) Puccinia

181. Consider the following statements about prions:
1. They contain single-stranded RNA as their genetic material.
2. They are infectious proteins that can cause neurodegenerative diseases.
3. They can be inactivated by standard autoclaving procedures.

Which of the statements given above is/are correct?
(A) 2 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

182. A key step in the life cycle of Ascomycetes and Basidiomycetes is karyogamy, which is the:
(A) Fusion of two somatic cells.
(B) Germination of a spore to form a hypha.
(C) Fusion of two haploid nuclei to form a diploid nucleus.
(D) Formation of asexual spores.

183. Which of the following statements about lichens is incorrect?
(A) They can colonize bare rocks and initiate soil formation.
(B) The algal partner is called the phycobiont.
(C) They are good indicators of air pollution.
(D) The fungal partner provides carbohydrates to the alga.

184. The cell walls of diatoms are known for their intricate patterns and are composed of opaline silica. These walls are called:
(A) Peplomers
(B) Frustules
(C) Tests
(D) Loricas

185. A student observes a fungus producing eight spores within a sac-like structure. This fungus belongs to the group:
(A) Basidiomycotina
(B) Zygomycotina
(C) Deuteromycotina
(D) Ascomycotina

186. The concept of "heterothallism" is functionally related to:
(A) The prevention of self-fertilization and promotion of outbreeding.
(B) Asexual reproduction.
(C) The nutritional requirements of the fungus.
(D) The formation of a parasitic relationship with a host.

187. Consider the following statements:
Statement I: In a mycorrhizal association, the fungus benefits by obtaining carbohydrates from the plant.
Statement II: The plant benefits as the fungal hyphae increase the surface area for water and phosphate absorption.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

188. In the five-kingdom classification system, bacteria are placed in the kingdom:
(A) Protista
(B) Fungi
(C) Monera
(D) Plantae

189. Which of the following is a characteristic of the algal division Rhodophyta?
(A) Presence of motile gametes with two flagella.
(B) Cell wall containing alginic acid.
(C) Primary photosynthetic pigments are chlorophylls a and b.
(D) Absence of any flagellated stage in the life cycle.

190. What is the cause of Creutzfeldt-Jakob disease (CJD) in humans?
(A) A retrovirus
(B) A prion

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(C) A viroid
(D) A mycoplasma

191. A bacteriophage that incorporates its genome into the host's chromosome and replicates with it is called a:
(A) Virulent phage
(B) Lytic phage
(C) Temperate phage
(D) Defective phage

192. Which of the following is an example of a beneficial activity of fungi?
(A) Causing ringworm in humans.
(B) Spoilage of food products.
(C) Causing Dutch elm disease.
(D) Production of citric acid by Aspergillus niger.

193. The main photosynthetic pigment in all algal groups and cyanobacteria is:
(A) Chlorophyll a
(B) Chlorophyll b
(C) Chlorophyll c
(D) Bacteriochlorophyll

194. A research student is studying an organism that causes rust on wheat. This pathogen, Puccinia, is an example of a(n):
(A) Facultative saprophyte
(B) Obligate parasite
(C) Facultative parasite
(D) Obligate saprophyte

195. Which of the following is NOT a method of genetic recombination in bacteria?
(A) Conjugation
(B) Transformation
(C) Meiosis
(D) Transduction

196. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Bacteriophages have a very narrow host range.
Reason (R): The attachment of a phage to a bacterium is a highly specific process involving receptor molecules on the bacterial surface.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

197. The term for the entire body of an alga, which lacks differentiation into true roots, stems, and leaves, is:
(A) Thallus
(B) Mycelium
(C) Rhizoid
(D) Stipe

198. Agar-agar, a product widely used in laboratories, is extracted from:
(A) Brown algae
(B) Red algae
(C) Green algae
(D) Blue-green algae

199. A 'clamp connection' is a structure found in some fungi that ensures:
(A) The fusion of hyphae from different mating types.
(B) The attachment of the fungus to its substrate.
(C) The proper nuclear distribution in daughter dikaryon cells.
(D) The rapid transport of nutrients along the hypha.

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200. Which statement accurately contrasts viruses and bacteria?
(A) Viruses have a cellular structure, while bacteria do not.
(B) Both viruses and bacteria can reproduce on non-living culture media.
(C) Bacteria are obligate intracellular parasites, while viruses are not.
(D) Bacteria possess both DNA and RNA, while viruses possess either DNA or RNA.

201. Match List I with List II regarding algal storage products:
List I: (Storage Product)
P. Starch
Q. Laminarin
R. Floridean Starch
S. Chrysolaminarin
List II: (Algal Group)
1. Phaeophyta

2. Rhodophyta
3. Bacillariophyta
4. Chlorophyta

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-1, R-4, S-3

202. The symptoms of mosaic, leaf rolling, yellowing, and stunting in plants are typically associated with:
(A) Viral infections
(B) Fungal infections
(C) Bacterial infections
(D) Mycoplasmal infections

203. A prokaryotic organism is found to perform oxygenic photosynthesis and has chlorophyll a and phycobilins. It lacks flagella. This organism belongs to:
(A) Archaebacteria
(B) Cyanobacteria
(C) Rhodophyta
(D) Chlorophyta

204. The primary composition of the cell wall in the majority of fungi is:
(A) Cellulose
(B) Peptidoglycan
(C) Chitin
(D) Silica

205. In fungi, the term 'coenocytic' describes hyphae that:
(A) Are divided by cross-walls or septa.
(B) Are organized into a complex fruiting body.
(C) Have specialized structures for trapping prey.
(D) Lack septa and are multinucleate.

206. Consider the following statements about Mycoplasma:
1. They are prokaryotes.
2. They possess a rigid cell wall made of peptidoglycan.
3. They are insensitive to antibiotics like penicillin.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

207. Which of the following represents the correct sequence of events during the parasexual cycle?
(A) Plasmogamy → Karyogamy → Mitotic crossing over → Haploidization
(B) Karyogamy → Plasmogamy → Haploidization → Mitotic crossing over
(C) Plasmogamy → Mitotic crossing over → Karyogamy → Haploidization
(D) Haploidization → Plasmogamy → Karyogamy → Mitotic crossing over

208. The main body of a fungus is composed of a network of fine, thread-like structures called:
(A) Mycelium
(B) Thallus
(C) Hyphae
(D) Rhizoids

209. The group Charophyta is considered to be the most likely ancestor of terrestrial plants based on which of the following shared characteristics?
(A) Presence of fucoxanthin and marine habitat.
(B) Similarities in cell division, sperm structure, and chlorophylls.
(C) Prokaryotic cell structure and nitrogen fixation ability.
(D) Sileceous cell walls and production of auxospores.

210. Consider the following statements:
Statement I: Prions are infectious agents responsible for diseases like scrapie in sheep.
Statement II: Prions are composed of a misfolded protein and lack nucleic acids.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

211. What is the key functional difference between the lytic and lysogenic cycles of a bacteriophage?
(A) The lytic cycle involves DNA, while the lysogenic cycle involves RNA.
(B) The lytic cycle causes host death, while lysogeny allows replication.
(C) The lytic cycle occurs in bacteria, while the lysogenic cycle occurs in viruses.

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(D) The lytic cycle is a form of sexual reproduction, while the lysogenic cycle is asexual.

212. To which group of fungi does the common bread mold, Rhizopus stolonifer, belong?
(A) Zygomycotina
(B) Mastigomycotina
(C) Ascomycotina
(D) Basidiomycotina

213. A key feature of the nutrition of Eubacteria is their:
(A) Universal ability to perform photosynthesis.
(B) Exclusive reliance on inorganic compounds for energy.
(C) Obligate parasitic nature, requiring a living host.
(D) Wide metabolic range including autotrophy and heterotrophy.

214. Which algal group is characterized by a "glass-like" cell wall that persists after the organism's death, forming diatomaceous earth?
(A) Chlorophyta
(B) Bacillariophyta
(C) Phaeophyta
(D) Rhodophyta

215. Aflatoxin, a carcinogenic substance, is a type of:
(A) Mycorrhiza
(B) Phyco-toxin
(C) Mycotoxin
(D) Bacteriocin

216. In which of the following microorganisms would you expect to find peptidoglycan in the cell wall?
(A) A yeast cell
(B) A Chlamydomonas cell
(C) A mycoplasma cell
(D) An E. coli cell

217. The most accurate description of a virus is:
(A) An acellular, obligate intracellular parasite.
(B) A primitive prokaryotic cell.
(C) A unicellular eukaryotic organism.
(D) A free-living, self-replicating nucleic acid.

218. The group of fungi known as 'club fungi', which includes mushrooms, puffballs, and rusts, is:
(A) Ascomycotina
(B) Basidiomycotina
(C) Zygomycotina
(D) Deuteromycotina

219. Arrange the following algal divisions from possessing the simplest pigments (in prokaryotes) to more complex accessory pigments (in deep-sea eukaryotes):
1. Chlorophyta
2. Rhodophyta
3. Cyanobacteria
4. Phaeophyta

(A) 3, 1, 4, 2
(B) 1, 3, 2, 4
(C) 3, 4, 1, 2
(D) 2, 4, 1, 3

220. Which of the following statements correctly describes a difference between viroids and virusoids?
(A) Viroids are infectious proteins, while virusoids are infectious RNAs.
(B) Viroids infect animals, while virusoids infect plants.
(C) Viroids replicate independently; virusoids need a helper virus.
(D) Viroids have a protein coat, while virusoids do not.

221. The economic importance of bacteria is vast. Which of the following is NOT a role played by bacteria?
(A) Curing of tea and tobacco.
(B) Formation of petroleum deposits from ancient diatoms.
(C) Production of vinegar and alcohol.
(D) Retting of fibers like jute and flax.

222. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Members of Deuteromycotina are considered "imperfect" fungi.
Reason (R): They reproduce exclusively by means of asexual spores called conidia, as their sexual stage is absent or has not been discovered.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct

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explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

223. The function of the holdfast in large seaweeds like kelp (Phaeophyta) is to:
(A) Absorb nutrients from the water.
(B) Carry out photosynthesis.
(C) Produce reproductive gametes.
(D) Anchor the alga to a substrate.

224. Which of the following characteristics is found in Cyanobacteria?
(A) Chlorophyll a and phycobilins.
(B) A membrane-bound nucleus.
(C) Mitochondria for respiration.
(D) Cell wall made of chitin.

225. A student is culturing a fungus that exhibits heterokaryosis. This means the mycelium of the fungus:
(A) Contains genetically identical nuclei.
(B) Contains genetically distinct nuclei in a common cytoplasm.
(C) Is diploid throughout its life cycle.
(D) Is incapable of sexual reproduction.

226. Match List I with List II regarding biological agents:
List I: (Agent)
P. Virus
Q. Viroid
R. Prion
S. Plasmid
List II: (Nature)
1. Infectious protein
2. Extrachromosomal DNA
3. Nucleic acid + Protein coat
4. Infectious RNA
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

227. In the context of viral diseases, what is the most effective method of control and prevention for the general population?
(A) Regular use of broad-spectrum antibiotics.
(B) Treatment with antifungal agents.
(C) Genetic modification of the human population.
(D) Implementation of widespread vaccination programs.

228. The 'red rust of tea' is a plant disease caused by a:
(A) Parasitic alga
(B) Fungus
(C) Bacterium
(D) Virus

229. A basidium, the characteristic reproductive structure of Basidiomycotina, typically bears how many spores?
(A) Eight
(B) Four
(C) Two
(D) An indefinite number

230. Consider the following statements regarding the ultra-structure of bacteria:
1. They possess 70S ribosomes.
2. Their genetic material is enclosed within a nuclear membrane.
3. The cell membrane can be invaginated to form mesosomes.
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

231. The cell wall of Oomycetes (e.g., Phytophthora) is primarily composed of:
(A) Chitin
(B) Peptidoglycan
(C) Silica
(D) Glucans and cellulose

232. An alga showing a parenchymatous thallus organization would look like:
(A) A flattened sheet or complex body of tissue-like cells.
(B) A single, motile cell.
(C) A long, unbranched thread of cells.
(D) A hollow ball of cells.

233. Consider the following statements:
Statement I: Lichens are pioneer colonizers of barren environments like bare rock.
Statement II: The fungus in the lichen secretes

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acids that help to break down the rock surface, initiating soil formation.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

234. Which of the following is NOT a characteristic of Archaebacteria?
(A) They thrive in extreme environments.
(B) Their cell membranes contain ether-linked lipids.
(C) Their cell walls contain peptidoglycan.
(D) They include methanogens, halophiles, and thermoacidophiles.

235. What is the fundamental role of pigments like chlorophylls and carotenoids in algae?
(A) To capture light energy for photosynthesis.
(B) To provide structural support to the cell wall.
(C) To act as a reserve food source.
(D) To protect the cell from viruses.

236. The group of organisms that are prokaryotic but perform oxygenic photosynthesis similar to plants are:
(A) Archaebacteria
(B) Cyanobacteria
(C) Fungi
(D) Viruses

237. If a fungus is homothallic, it means that:
(A) It requires two different mating types to reproduce sexually.
(B) It can only reproduce asexually.
(C) It can reproduce sexually from a single thallus (self-fertile).
(D) Its mycelium contains two distinct types of nuclei.

238. A scientist observes that a particular bacterial culture is resistant to the antibiotic kanamycin. This resistance is most likely conferred by a gene located on:
(A) A ribosome
(B) The primary chromosome
(C) The cell wall
(D) An extrachromosomal plasmid

239. The most common form of thallus organization in Phaeophyta (brown algae) is:
(A) Unicellular and motile
(B) Large, complex, and parenchymatous
(C) Simple unbranched filament
(D) Colonial and non-motile

240. Which of the following diseases is caused by a fungus?
(A) Ringworm
(B) Polio
(C) Smallpox
(D) Cholera

241. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Mycoplasmas are considered "pleomorphic".
Reason (R): They lack a rigid cell wall, which allows them to assume various shapes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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242. The process of viral entry into an animal cell where the host cell membrane engulfs the entire virus is called:
(A) Injection
(B) Lysis
(C) Endocytosis
(D) Conjugation

243. The flagellation in the algal class Xanthophyta is typically:
(A) Isokont (two equal, whiplash flagella)
(B) Stephanokont (a ring of flagella)
(C) Akont (no flagella)
(D) Heterokont (two unequal flagella, one tinsel and one whiplash)

244. A major difference between Mastigomycotina and Zygomycotina is:
(A) Mastigomycotina produce motile spores, while Zygomycotina do not.
(B) Mastigomycotina have chitin in their cell walls, while Zygomycotina have cellulose.

(C) Mastigomycotina are all terrestrial, while Zygomycotina are all aquatic.
(D) Mastigomycotina are septate, while Zygomycotina are aseptate.

245. Identify the incorrect statement regarding the biological importance of algae.
(A) They are major primary producers in aquatic ecosystems.
(B) All algal blooms are beneficial for aquatic life.
(C) They release a significant portion of the Earth's atmospheric oxygen.
(D) They are a source of commercial products like agar and alginates.

246. Which of the following is a key characteristic of the Bacteriophage replication cycle?
(A) The phage replicates in the host nucleus.
(B) The entire phage particle enters the bacterial cell.
(C) The phage injects its nucleic acid into the host.
(D) The phage uses its own ribosomes for protein synthesis.

247. A "dikaryon" or "dikaryotic phase" in the fungal life cycle refers to a cell or mycelium where:
(A) The nucleus is diploid.
(B) There is only one haploid nucleus per cell.
(C) The cell lacks a nucleus.
(D) Two distinct haploid nuclei coexist and divide.

248. Consider the following events in a fungal life cycle:
1. Karyogamy
2. Meiosis
3. Plasmogamy

Which of the following is the correct sequence for sexual reproduction?
(A) 1, 2, 3
(B) 3, 1, 2
(C) 2, 3, 1
(D) 3, 2, 1

249. Which one of the following is a characteristic feature of Rickettsia?
(A) They are obligate intracellular prokaryotic parasites.
(B) They are free-living saprophytes.
(C) They lack a cell wall.
(D) They are infectious protein particles.

250. Match List I with List II regarding fungal structures and groups:
List I: (Fungal Structure)
P. Clamp Connection
Q. Zygospore
R. Ascocarp
S. Zoospore
List II: (Group)
1. Ascomycotina
2. Basidiomycotina
3. Mastigomycotina
4. Zygomycotina
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-2, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

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251. The ultra-structure of a typical virus always includes:
(A) A nucleus and cytoplasm.
(B) A nucleic acid genome and a capsid.
(C) A cell wall and a cell membrane.
(D) Ribosomes and mitochondria.

252. The term 'Actinomycetes' refers to a group of bacteria that are noted for:
(A) Their fungus-like growth and antibiotic production.
(B) Their photosynthetic ability.
(C) Their lack of a cell wall.
(D) Their ability to survive in extremely high temperatures.

253. Consider the following statements:
Statement I: The brown color of Phaeophyta is due to the pigment fucoxanthin.
Statement II: The red color of Rhodophyta is due to the pigment phycoerythrin.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

254. A researcher wants to isolate an organism that is known to cause a disease characterized by "witches' brooms" in plants. This pathogenic organism is most likely a:

(A) Virus
(B) Prion
(C) Viroid
(D) Mycoplasma

255. In the classification of fungi, which of the following is NOT a major subdivision (ending in -mycotina)?
(A) Zygomycotina
(B) Sordariomycotina
(C) Ascomycotina
(D) Chytridiomycotina

256. Which of the following is a common mode of asexual reproduction in yeast?
(A) Fragmentation
(B) Conidia formation
(C) Budding
(D) Zoospore formation

257. A key difference between Eubacteria and Cyanobacteria is that:
(A) Eubacteria are prokaryotic, while Cyanobacteria are eukaryotic.
(B) Eubacteria have peptidoglycan walls, while Cyanobacteria do not.
(C) Eubacteria lack ribosomes, while Cyanobacteria have them.
(D) Many Eubacteria are heterotrophic, while Cyanobacteria are photosynthetic.

258. Consider the following characteristics:
1. Prokaryotic cell structure
2. Can live in extreme environments
3. Cell wall lacks peptidoglycan
Which of the following organisms exhibit these features?
(A) Eubacteria
(B) Archaebacteria
(C) Cyanobacteria
(D) Mycoplasma

259. The study of fungi is known as:
(A) Phycology
(B) Mycology
(C) Virology
(D) Bacteriology

260. Which of the following groups of algae is considered to be most closely related to the ancestors of land plants?
(A) Rhodophyta
(B) Phaeophyta
(C) Charophyta
(D) Bacillariophyta

261. An endomycorrhiza is characterized by:
(A) A dense sheath of fungus (mantle) covering the root surface.
(B) The fungus being visible on the outside of the root.
(C) The fungus parasitizing and killing the plant root.
(D) Fungal hyphae penetrating into the root cortical cells.

262. In a lytic infection, the host cell is ultimately destroyed. This destruction is called:
(A) Lysis
(B) Fusion
(C) Endocytosis
(D) Budding

263. Asexual reproduction in Spirogyra occurs by:
(A) Zoospores
(B) Fragmentation
(C) Aplanospores
(D) Hormogonia

264. The primary reason algae are classified separately from plants is that:
(A) Algae are not photosynthetic.
(B) Algae are all unicellular.
(C) Algae lack complex reproductive structures and tissues.
(D) Algal cell walls are made of chitin.

265. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Antibiotics like penicillin are ineffective against viral infections.
Reason (R): Viruses lack the metabolic pathways and structures, such as a cell wall, that are targeted by most antibiotics.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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266. Arrange the following stages of a fungal sexual life cycle in the correct order:
1. Meiosis
2. Spore Germination
3. Plasmogamy
4. Karyogamy

(A) 3, 4, 1, 2
(B) 4, 3, 1, 2
(C) 3, 1, 4, 2
(D) 2, 3, 1, 4

267. The shell of a diatom is called a frustule and is made up of:
(A) Calcium carbonate
(B) Chitin
(C) Cellulose
(D) Silica

268. Which of the following is NOT a mode of nutrition found in bacteria?
(A) Holozoic
(B) Saprophytic
(C) Photosynthetic
(D) Chemosynthetic

269. The 'little leaf' disease of brinjal is caused by a:
(A) Virus
(B) Fungus
(C) Mycoplasma
(D) Viroid

270. In a lichen, what does the phycobiont (algal partner) provide to the mycobiont (fungal partner)?
(A) Water and minerals
(B) Carbohydrates from photosynthesis
(C) Protection from desiccation
(D) Anchorage to the substrate

271. Which statement best describes the genetic material of prokaryotes like bacteria?
(A) Multiple linear chromosomes enclosed in a nucleus.
(B) Multiple circular plasmids but no primary chromosome.
(C) A single linear DNA molecule complexed with histone proteins.
(D) A single, circular DNA molecule in a nucleoid region.

272. A fungus that can grow as either a single-celled yeast or a multicellular mold depending on environmental conditions is called:
(A) Dimorphic
(B) Heterothallic
(C) Coenocytic
(D) Homothallic

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273. Consider the following statements:
Statement I: The parasexual cycle involves plasmogamy, karyogamy, and meiosis.
Statement II: The parasexual cycle is a means of genetic recombination that bypasses the regular sexual cycle.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

274. Heterocysts in Cyanobacteria are specialized for nitrogen fixation because they:
(A) Are the primary sites of photosynthesis.
(B) Have thickened walls to maintain an anaerobic environment.
(C) Store large amounts of reserve food material.
(D) Are motile and can move to nitrogen-rich areas.

275. A key difference between Chlorophyta and Phaeophyta is the:
(A) Presence of a cell wall.
(B) Eukaryotic cell structure.
(C) Type of chlorophyll and accessory pigments.
(D) Ability to perform photosynthesis.

276. Consider the following statements about host-parasite relationships in plant pathology:
1. An obligate parasite can only survive on a living host.
2. A facultative saprophyte is primarily a parasite but can live on dead matter.
3. A biotroph is a parasite that keeps its host alive.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 1, 2 and 3
(D) 3 only

277. The term for the mass of hyphae that constitutes the vegetative body of a fungus is:
(A) Thallus
(B) Stroma
(C) Sporangium
(D) Mycelium

278. The transmission of a virus from a mother to her child during pregnancy or birth is an example of:
(A) Vertical transmission
(B) Horizontal transmission
(C) Vector transmission
(D) Zoonotic transmission

279. Which of the following is a characteristic of all members of the Kingdom Fungi?
(A) They are all multicellular.
(B) They are all eukaryotic.
(C) They are all saprophytes.
(D) They all reproduce sexually.

280. A scientist analyzing a newly discovered microorganism finds it is unicellular, lacks a nucleus, has a cell wall containing peptidoglycan, and is sensitive to penicillin. This organism is a:
(A) Virus
(B) Archaebacterium
(C) Eubacterium
(D) Fungus

281. Match List I with List II regarding microbiological terms:
List I: (Term)
P. Capsid
Q. Prophage
R. Viroid
S. Prion
List II: (Description)
1. Infectious RNA
2. Integrated viral DNA
3. Protein coat of virus
4. Infectious protein
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-2, S-3

282. The unique feature of a dikaryotic cell in the fungal life cycle is that it contains:
(A) Two diploid nuclei.
(B) One diploid nucleus.
(C) Two haploid nuclei which have not yet fused.
(D) No nucleus, but two sets of chromosomes.

283. Which of the following is a correct statement about algal classification?
(A) All algae with chlorophyll b are placed in Chlorophyta.
(B) Pigmentation, reserve food, and flagellation are key criteria.
(C) Thallus structure is not considered an important taxonomic character.
(D) All prokaryotic algae are placed in Rhodophyta.

284. The enzyme nitrogenase, critical for nitrogen fixation, is highly sensitive to:
(A) Carbon dioxide
(B) Nitrogen
(C) Water
(D) Oxygen

285. A case study describes a massive fish kill in a coastal area following a rapid, dense growth of a single-celled photosynthetic organism. This event is known as a(n):
(A) Algal bloom
(B) Mycorrhizal bloom
(C) Fungal bloom
(D) Bacterial bloom

286. The following question consists of two statements: Assertion (A) and Reason (R). Answer the question by selecting the appropriate option:
Assertion (A): Oogamy in algae is considered an advanced type of sexual reproduction.
Reason (R): It involves the fusion of a large, non-motile female gamete (egg) with a smaller, motile male gamete.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

287. Which of the following is NOT a general characteristic of the Fungi?
(A) Eukaryotic cell organization

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(B) Autotrophic mode of nutrition
(C) Cell wall made of chitin
(D) Storage of food as glycogen

288. Viruses are considered to be on the borderline of living and non-living because:
(A) They are unicellular but lack a nucleus.
(B) They have a cell wall but no cell membrane.
(C) They can be crystallized like chemicals but can replicate in a host.
(D) They contain DNA but no RNA.

289. The 'rusts' and 'smuts' that cause significant diseases in cereal crops are caused by fungi belonging to the group:
(A) Zygomycotina
(B) Ascomycotina
(C) Deuteromycotina
(D) Basidiomycotina

290. What is the primary role of the mycobiont in a lichen symbiosis?
(A) To provide structural support, protection, and absorb water/minerals.
(B) To perform photosynthesis and provide food.
(C) To fix atmospheric nitrogen for the partnership.
(D) To produce motile spores for dispersal.

291. A key diagnostic feature of the algal division Phaeophyta is the presence of:
(A) Chlorophylls a and b.
(B) Phycobilin pigments like phycoerythrin.
(C) The brown pigment fucoxanthin.
(D) A prokaryotic cell structure.

292. In a typical bacterial growth curve, the phase where cells are rapidly dividing at a constant rate is the:
(A) Log (exponential) phase
(B) Lag phase
(C) Stationary phase
(D) Death phase

293. Which of the following groups includes organisms that are prokaryotic?
(A) Chlorophyta and Phaeophyta
(B) Archaebacteria and Eubacteria
(C) Rhodophyta and Charophyta
(D) Ascomycotina and Basidiomycotina

294. Consider the following statements:
Statement I: Viroids are the smallest infectious agents known.
Statement II: Viroids are composed of a naked, circular, single-stranded RNA molecule.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

295. The sexual spores produced endogenously in a sac-like structure are called ascospores, which is characteristic of:
(A) Basidiomycotina
(B) Zygomycotina
(C) Ascomycotina
(D) Mastigomycotina

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296. The process of binary fission in bacteria is a method of:
(A) Sexual reproduction
(B) Genetic recombination
(C) Dormancy
(D) Asexual reproduction

297. Which of the following is true for all viruses?
(A) They are obligate intracellular parasites.
(B) They have a DNA genome.
(C) They have a lipid envelope.
(D) They contain their own ribosomes.

298. Mycorrhizae are associations that are beneficial to plants primarily because they:
(A) Protect the plant from insect pests.
(B) Increase surface area for water and mineral absorption.
(C) Produce sugars for the plant through photosynthesis.
(D) Fix atmospheric nitrogen into ammonia.

299. An alga with a siphonaceous thallus, like Vaucheria, is characterized by being:
(A) A colony of individual cells.
(B) A multicellular, leafy structure.
(C) A single, large, multinucleate cell (coenocytic).
(D) A simple, unbranched filament of cells.

300. The kingdom Monera includes:
(A) All unicellular eukaryotes.

(B) Eubacteria and Archaebacteria.
(C) Fungi and algae.
(D) Viruses and prions.

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ANSWERS

1. (B) An acellular parasite containing a nucleic acid core and protein capsid.
Viruses are non-cellular entities consisting of a genetic material core, either DNA or RNA, enclosed within a protective protein layer known as a capsid. They lack the necessary metabolic machinery for independent life and must inhabit a living host cell to replicate. These obligate parasites represent a unique category of pathogens distinct from prokaryotic microorganisms.

2. (A) Viral genetic material consists of either DNA or RNA, but never both.
The genetic architecture of viruses is characterized by the presence of a single type of nucleic acid, which can be either deoxyribonucleic acid or ribonucleic acid. Unlike cellular life forms that utilize both DNA and RNA for different functions, a specific viral species will exclusively contain one or the other, serving as the blueprint for replication.

3. (A) Both Statement I and Statement II are true.
Viroids represent a class of sub-viral pathogens that are significantly smaller than traditional viruses. They are composed entirely of a short, circular, single-stranded RNA molecule that lacks any protein encapsulation or capsid. These infectious agents primarily target plants, disrupting normal cellular processes through their unique molecular structure and replication mechanism within the host cells of various botanical species.

4. (D) Prion
Prions are specialized infectious agents composed exclusively of protein, lacking any detectable nucleic acid components like DNA or RNA. These misfolded proteins induce abnormal folding in normal cellular proteins, primarily within the central nervous system. This process leads to severe neurodegenerative conditions such as spongiform encephalopathies, characterized by the development of tiny holes in the affected brain tissue.

5. (C) Through binary fission.
Viral particles spread through diverse mechanisms including insect vectors, contaminated food, water, or airborne droplets produced by respiratory actions. Unlike bacteria that reproduce via binary fission, viruses must hijack a host cell's machinery to replicate. Consequently, binary fission is not a method for transferring viral infections between individuals, as viruses are acellular and do not undergo cell division.

6. (A) Both A and R are true and R is the correct explanation of A.
Bacteriophages are specialized viruses that exclusively infect and replicate within bacterial hosts. Their life cycle begins by attaching to the bacterial surface and injecting their genetic material into the cell. Once inside, the viral genome takes control of the host's metabolic machinery to synthesize new viral components, eventually leading to the assembly and release of numerous progeny virions.

7. (D) To protect the viral nucleic acid.
The capsid is a critical structural component of a virus, serving as a protective shell made of protein subunits. Its primary biological function is to safeguard the internal viral genome from environmental degradation and enzymatic attack. Additionally, the capsid often facilitates the attachment of the viral particle to specific receptor sites on the surface of a suitable host cell.

(A) They act as obligate intracellular parasites.
Mycoplasma are unique prokaryotes recognized as the smallest free-living organisms currently known to science. Unlike most bacteria, they entirely lack a rigid cell wall, making them naturally resistant to antibiotics that target wall synthesis. While they can cause various diseases, they are generally not obligate intracellular parasites, as they possess the metabolic capacity to grow on specialized artificial media.

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9. (C) The host cell is lysed to release new phage particles.
The lytic cycle is a primary method of viral replication where the bacteriophage hijacks the host bacterium's machinery to produce new virions. This process culminates in the production of specific enzymes that degrade the bacterial cell wall. The subsequent rupture or lysis of the host cell allows the newly formed infectious phage particles to escape into the surrounding environment.

10. (A) P-2, Q-4, R-1, S-3
Pathogens are classified by their unique structural and infectious properties. Prions are purely proteinaceous infectious particles, while viroids consist solely of infectious RNA without a protein coat. Mycoplasmas are characterized by the absence of a cell wall. Rickettsia represent a group of small bacteria that function as obligate intracellular parasites, requiring a living host cell for survival and replication.

11. (D) Single-stranded RNA
The Tobacco Mosaic Virus is a classic example of a plant virus with a well-defined molecular structure. Its genome consists of a single-stranded ribonucleic acid molecule. This RNA core is surrounded by a helical arrangement of protein subunits called capsomeres. This specific genetic configuration is responsible for directing the synthesis of viral components once the virus infects tobacco plant cells.

12. (B) A complex structure with an icosahedral head and a tail.
T-even bacteriophages exhibit a complex structural organization often described as a tadpole-like shape. This architecture includes an icosahedral head, which encapsulates the viral DNA, and a tail assembly used for attachment and genome injection. The tail typically consists of a contractile sheath, a base plate, and tail fibers that facilitate the specific recognition and infection of bacterial hosts.

13. (B) 1 and 2 only
Plasmids are small, circular, extrachromosomal DNA molecules found within bacterial cells. They possess the ability to replicate independently of the main genomic chromosome. While they often carry beneficial genes, such as those for antibiotic resistance or toxin production, they are generally not required for the basic survival of the bacterium under standard, non-stressful environmental conditions in the laboratory or nature.

14. (D) Actinomycetes
Actinomycetes are a group of Gram-positive bacteria that exhibit a filamentous growth pattern reminiscent of fungi. They are biologically significant because they produce a vast array of secondary metabolites. In medical science, these organisms are the primary source for many essential antibiotics, including streptomycin and tetracycline, which are used to treat various bacterial infections in humans and other animals.

15. (A) Circular ssRNA molecules requiring a helper virus.
Virusoids are small, circular, single-stranded RNA molecules that are infectious but fundamentally different from viroids. Their primary distinguishing feature is the requirement of a specific helper virus for both replication and encapsulation. The virusoid RNA is packaged within the protein capsid of the helper virus, which facilitates its transmission and entry into suitable host cells, predominantly within various plant species.

16. (B) Virus
Plant viruses induce a range of systemic symptoms as they interfere with the host's physiological processes. Yellowing, mottling patterns, and leaf curling are classic indicators of viral infection. These abnormalities result from the virus disrupting chlorophyll production and hormonal balance within the plant tissues. Such visible changes reflect the underlying replication of the virus and the subsequent stress on the host.

17. (B) Presence of ether-linked lipids in the cell membrane
Archaebacteria are distinguished from Eubacteria primarily by the unique chemical composition of their cell membranes. While Eubacteria have membranes with ester-linked fatty acids, Archaebacteria possess ether-linked lipids. This molecular adaptation provides enhanced stability and resistance, allowing these organisms to thrive in extreme environments such as hydrothermal

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vents, highly acidic springs, and salt lakes where most other life forms cannot survive.

18. (A) 3, 2, 5, 1, 4
The replication of a lytic virus follows a strict chronological sequence to ensure successful infection. It begins with the attachment to the host surface, followed by the penetration of viral genetic material into the cell. The host machinery is then hijacked for the synthesis of viral components, which are subsequently assembled into new particles before being released through cell lysis.

19. (C) Prion - Nucleic acid core
Pathogenic agents are classified based on their fundamental structural components. Tobacco Mosaic Virus exhibits helical symmetry, while bacteriophages often have a complex tadpole shape. Adenoviruses are known for their icosahedral symmetry. However, prions are unique because they are composed entirely of misfolded proteins. Unlike viruses and viroids, prions do not contain any nucleic acid core, such as DNA or RNA.

20. (D) Obligate intracellular energy parasites.
Chlamydia are highly specialized bacteria that function as obligate intracellular parasites. They are uniquely characterized as energy parasites because they lack the metabolic pathways to produce their own adenosine triphosphate. Instead, they must inhabit a host cell and utilize the host's energy resources for their replication and survival, alternating between distinct infectious and reproductive forms during their complex life cycle.

21. (A) Both A and R are true and R is the correct explanation of A.
Penicillin and related beta-lactam antibiotics function by interfering with the synthesis of peptidoglycan, the primary component of the bacterial cell wall. Because mycoplasmas naturally lack a cell wall, they are fundamentally resistant to these drugs. This structural absence renders the antibiotic's mechanism of action irrelevant, allowing mycoplasmas to survive treatments that would typically be lethal to most other bacterial species.

22. (B) Lysogenic cycle
The lysogenic cycle is a sophisticated viral replication strategy where the bacteriophage genome incorporates itself into the host bacterium's chromosome. Once integrated, the viral DNA, now called a prophage, remains dormant and is replicated alongside the bacterial DNA during every cell division. This allows the virus to persist within a bacterial population without immediately killing the host cells through lysis.

23. (D) Capsomere
The protective protein shell of a virus, known as the capsid, is constructed from numerous individual protein subunits. These repeating structural units are called capsomeres. Their specific arrangement determines the overall symmetry and shape of the virus particle, whether it is helical, icosahedral, or complex. Capsomeres are essential for shielding the viral genetic material and facilitating the infection of new hosts.

24. (A) Heterotrophic (saprophytic or parasitic)
Most bacteria are characterized by a heterotrophic mode of nutrition, meaning they obtain their energy and carbon by consuming organic compounds. This lifestyle often involves acting as saprophytes that decompose dead matter or as parasites that inhabit living hosts. While some specialized bacteria are autotrophic, the vast majority rely on the absorption of nutrients from their surrounding environment to survive.

25. (C) A well-defined nucleus with a membrane.
Eubacteria are prokaryotic organisms characterized by a simple cellular organization that lacks a membrane-bound nucleus. Instead, their genetic material consists of a single circular chromosome located in a region called the nucleoid. They possess a cell wall usually made of peptidoglycan and 70S ribosomes for protein synthesis. The absence of a defined nucleus is a fundamental distinction from eukaryotic cells.

26. (A) They possess chloroplasts for photosynthesis.
Cyanobacteria are photosynthetic prokaryotes that perform oxygenic photosynthesis, using chlorophyll a to harvest light energy. Unlike eukaryotic plants and algae, they do not possess chloroplasts; instead, their photosynthetic

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pigments and machinery are located on internal thylakoid membranes within the cell. Some species are also capable of fixing atmospheric nitrogen into ammonia, which is an ecologically vital process in various aquatic environments.

27. (D) Antibiotic production, dairy fermentation, and nitrogen fixation.
Bacteria play diverse and essential roles in human industry and ecology. They are instrumental in the production of various antibiotics used in modern medicine. In the food industry, they are used for dairy fermentation to create products like yogurt and cheese. Furthermore, nitrogen-fixing bacteria are crucial for soil fertility, as they convert atmospheric nitrogen into a form that plants can utilize.

28. (B) 1 and 3 only
Bacterial populations primarily increase through binary fission, a rapid form of asexual reproduction where a single cell divides into two identical daughters. While bacteria do not undergo sexual reproduction involving meiosis, they achieve genetic diversity through recombination. This occurs via transformation, where they take up external DNA, transduction involving viruses, and conjugation, which requires direct cell-to-cell contact for plasmid transfer.

29. (C) Chemoautotroph
A chemoautotroph is an organism that synthesizes its own organic molecules using energy derived from the oxidation of inorganic chemical compounds. These bacteria do not require light for energy, instead utilizing substances like ammonia, hydrogen sulfide, or ferrous iron. By harnessing these chemical reactions, they can fix carbon dioxide into sugars, playing a vital role as primary producers in environments without sunlight.

30. (D) Heterocysts
Heterocysts are specialized, thick-walled cells found in certain filamentous cyanobacteria that serve as the primary site for atmospheric nitrogen fixation. Because the enzyme nitrogenase is highly sensitive to oxygen, heterocysts create an anaerobic environment by lacking the oxygen-producing parts of the photosynthetic machinery. This allows the bacteria to convert nitrogen gas into ammonia even while living in oxygen-rich aquatic habitats.

31. (B) P-3, Q-2, R-4, S-1
Bacterial cells possess specialized structures that facilitate their survival and reproduction. Flagella provide motility, allowing the bacteria to move through liquid environments. Pili are involved in attachment to surfaces and the process of conjugation. The capsule provides a protective layer that can shield the cell from phagocytosis. Finally, ribosomes are the universal cellular machines responsible for the synthesis of all bacterial proteins.

32. (B) They are absorptive heterotrophs.
Fungi are a distinct kingdom of eukaryotic organisms characterized by an absorptive heterotrophic mode of nutrition. They do not ingest food like animals or produce it through photosynthesis like plants. Instead, they secrete powerful digestive enzymes into their surrounding environment to break down complex organic matter. The resulting simple nutrients are then absorbed directly through their cell walls and plasma membranes for growth.

33. (A) Both Statement I and Statement II are true.
The structural integrity of most fungal cells is provided by a cell wall primarily composed of the polysaccharide chitin. This distinguishes them from plants, which use cellulose. However, within the group Mastigomycotina, the oomycetes are an exception, as their cell walls are mainly made of cellulose and glucans. Understanding these chemical differences is crucial for the proper classification and study of fungi.

34. (A) Zygomycotina
Zygomycotina is a group of fungi characterized by the presence of coenocytic hyphae, which are multinucleate filaments lacking cross-walls or septa. Their sexual reproduction involves the fusion of specialized gametangia, resulting in the formation of a thick-walled, resistant structure known as a zygospore. This group includes common molds such as those found on bread, which utilize these spores to survive unfavorable environmental conditions.

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35. (C) Heterokaryosis
Heterokaryosis is a biological phenomenon in fungi where two or more genetically distinct nuclei inhabit and divide within the same cytoplasm of a single hyphal segment. This condition often arises through the fusion of hyphae from different individuals, a process called plasmogamy. It allows the fungus to maintain genetic diversity and potentially benefit from the combined physiological capabilities of different nuclear types.

36. (A) Both A and R are true and R is the correct explanation of A.
The group Deuteromycotina is commonly known as the "Fungi Imperfecti" because their life cycles appear incomplete compared to other fungal groups. This classification is used for fungi where a sexual stage of reproduction has never been observed or is naturally absent. These organisms reproduce primarily through asexual means, such as the production of conidia, and are often reclassified once their sexual phase is discovered.

37. (C) Ascospore
Members of the Ascomycotina are characterized by the production of a specific type of sexual spore called an ascospore. These spores develop within a microscopic, sac-like structure known as an ascus, which typically contains eight ascospores following meiosis and a subsequent mitotic division. This internal development of sexual spores is a defining feature that separates this group from other major fungal divisions.

38. (B) A fungus and the roots of a higher plant.
Mycorrhiza is a mutually beneficial symbiotic association formed between the mycelium of certain fungi and the roots of higher plants. In this relationship, the fungal hyphae extend far into the soil, increasing the plant's surface area for the absorption of water and essential minerals like phosphorus. In return, the plant provides the fungus with energy-rich carbohydrates produced during the process of photosynthesis.

39. (D) Toxic mycotoxins produced by molds on crops.
Aflatoxins are highly toxic and carcinogenic substances produced as secondary metabolites by certain molds, particularly species of Aspergillus. These mycotoxins frequently contaminate agricultural crops like peanuts and corn when they are stored in warm, humid conditions. Ingesting food contaminated with these toxins can lead to severe liver damage and cancer, making their detection a critical aspect of food safety and public health.

40. (A) All fungi are multicellular.
While the vast majority of fungi are multicellular organisms that grow as a network of hyphae, the kingdom also includes unicellular forms. Yeasts are a prominent example of single-celled fungi that reproduce through budding or fission. All fungi share eukaryotic cell structures, store their energy as glycogen, and typically reproduce via spores, but they are not universally multicellular in their organization.

41. (C) Meiotic division and sexual structures.
The parasexual cycle is a non-standard genetic process in certain fungi that allows for the recombination of genetic material. Unlike traditional sexual reproduction, it does not involve the formation of specialized sexual structures or the process of meiosis. Instead, it relies on the occasional fusion of nuclei within a heterokaryotic mycelium, followed by mitotic crossing-over and a gradual loss of chromosomes.

42. (A) Mastigomycotina
Mastigomycotina is a fungal group characterized by the production of motile asexual spores known as zoospores. These spores are equipped with one or more flagella, allowing them to swim through water or thin films of moisture to find new substrates or hosts. This aquatic adaptation distinguishes them from other major fungal groups that rely on non-motile spores dispersed by wind or insects.

43. (D) An ectoparasite
An ectoparasite is an organism that lives on the external surface of its host, deriving nutrients without entering the internal tissues. Powdery mildew, caused by fungi like Erysiphe, is a classic example of this relationship. The fungal mycelium grows primarily on the leaf surface, appearing as white patches, and uses specialized structures called haustoria to penetrate only the outermost epidermal cells.

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44. (C) 2 and 3 only
Lichens are complex symbiotic organisms resulting from a partnership between a fungal mycobiont and a photosynthetic phycobiont, which can be an alga or a cyanobacterium. In most lichens, the fungal partner belongs to the Ascomycete group. This association is so integrated that they function as a single unit, colonizing harsh environments where neither partner could survive independently, such as bare rocks.

45. (C) Basidiomycotina
Clamp connections are unique bridge-like structures found in the hyphae of many Basidiomycotina. They play a vital role during cell division in dikaryotic mycelia, ensuring that each new cell receives one nucleus from each of the two different parental mating types. By facilitating this precise nuclear distribution, clamp connections maintain the dikaryotic state, which is a prerequisite for forming complex fruiting bodies.

46. (D) Saccharomyces cerevisiae
Saccharomyces cerevisiae, commonly known as brewer's or baker's yeast, is a fungus of immense economic importance. In the baking industry, it performs fermentation, producing carbon dioxide that causes dough to rise. In brewing, it converts sugars into ethanol and carbon dioxide. This unicellular fungus is also widely used in biotechnology and genetic research due to its well-understood biology and ease of cultivation.

47. (A) The requirement of two compatible mating types for sexual reproduction.
Heterothallism is a reproductive strategy in fungi where sexual reproduction can only occur between two compatible individuals belonging to different mating types. This requirement prevents self-fertilization and promotes genetic diversity within the population through outbreeding. In heterothallic species, a single isolated thallus is self-sterile and must encounter a suitable partner to complete its sexual life cycle and produce recombinant spores.

48. (B) Mycotoxins
Mycotoxins are toxic chemical compounds produced by certain molds that colonize agricultural crops like corn, wheat, and nuts. When livestock or humans consume contaminated feed or food, these toxins can cause a variety of health problems, ranging from acute poisoning to chronic conditions like cancer. Managing mold growth during harvest and storage is essential to prevent mycotoxin accumulation and ensure food safety.

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49. (B) Type of photosynthetic pigments and reserve food material.
Algae are mainly classified based on the type of photosynthetic pigments they contain and their reserve food materials. Different groups of algae possess distinct pigments such as chlorophylls, carotenoids, and phycobilins, which determine their color and light-absorbing ability. They also store food in different forms like starch, laminarin, or oils. These biochemical differences help scientists divide algae into major groups such as green, brown, and red algae.

50. (A) Volvox
Volvox is a well-known genus of green algae that exhibits a colonial form of thallus organization. It consists of thousands of individual cells embedded in a hollow, spherical gelatinous matrix. These cells are coordinated by cytoplasmic bridges, allowing the colony to move and orient itself toward light. This level of organization represents an evolutionary transition from simple unicellular life to more complex multicellularity.

51. (A) P-4, Q-1, R-2, S-3
Algal divisions are distinguished by their unique pigments and storage molecules. Chlorophyta use chlorophylls a and b and store starch. Phaeophyta contain fucoxanthin and store laminarin. Rhodophyta possess phycobilins and store floridean starch. Bacillariophyta, or diatoms, are characterized by silica-based cell walls called frustules and the storage of chrysolaminarin. These traits reflect their diverse evolutionary paths and adaptations to different aquatic environments.

52. (D) Bacterial decomposition of dead algae depletes oxygen.
Algal blooms occur when nutrient-rich water triggers rapid population growth of algae. While the living algae produce oxygen, their eventual death leads to a significant ecological problem. Aerobic bacteria decompose the dead

algal biomass, consuming massive amounts of dissolved oxygen in the process. This depletion of oxygen creates “dead zones” where fish and other aquatic organisms cannot survive, leading to mass mortality.

53. (C) Rhodophyta (Red algae)
Rhodophyta, or red algae, are distinguished by a complete absence of flagellated cells at any stage of their life cycle. Neither their vegetative cells nor their reproductive cells, such as gametes and spores, possess flagella. Instead, they rely on water currents for the dispersal of their non-motile reproductive units. This unique characteristic separates them from most other algal groups, which typically have motile stages.

54. (B) Red algae like Gelidium and Gracilaria.
Agar is a commercially valuable gelatinous substance extracted from the cell walls of certain red algae, particularly members of the genera Gelidium and Gracilaria. It is widely used in microbiology as a solidifying agent for culture media because most bacteria cannot digest it. Additionally, agar finds applications in the food industry as a thickener and stabilizer in various products like jellies.

55. (D) Chlorophyll a and b, but are strictly prokaryotic.
Prochlorophyta represent a unique group of prokaryotic organisms that possess both chlorophyll a and chlorophyll b. This pigment composition is similar to that of eukaryotic green algae and land plants but differs from most other cyanobacteria, which lack chlorophyll b. Despite their plant-like pigments, they are strictly prokaryotic in their cellular organization, lacking a nucleus and membrane-bound organelles like chloroplasts.

56. (A) Both A and R are true and R is the correct explanation of A.
Diatoms are ecologically and economically significant algae characterized by cell walls made of silica, known as frustules. Because silica is highly resistant to decomposition, these walls persist long after the organisms die. Over geological timescales, the accumulation of billions of these microscopic shells forms massive deposits called diatomaceous earth, which is harvested for use in filtration, insulation, and abrasive products.

57. (C) Laminarin and mannitol
Members of the Phaeophyta, or brown algae, primarily store their photosynthetic energy in the form of complex carbohydrates. The most common reserve food materials are laminarin, a polysaccharide, and mannitol, a sugar alcohol. These molecules are stored within the cells and can be utilized during periods of low light or for reproduction, providing a reliable energy source in their marine habitats.

58. (A) They are considered the closest living relatives of land plants.
Charophyta is a group of green algae that exhibits a high degree of structural complexity, including specialized reproductive organs. They are of great evolutionary interest because they share several fundamental characteristics with land plants, such as similar methods of cell division and sperm structure. Consequently, they are widely regarded by biologists as the closest living relatives to the ancestors of all terrestrial vegetation.

59. (D) Xanthophyta
Xanthophyta, commonly known as yellow-green algae, are typically unicellular or filamentous organisms found in freshwater environments. They are characterized by the presence of chlorophyll a and c, but their color is dominated by an abundance of xanthophyll pigments. These algae typically possess two unequal flagella and store their reserve food as oils or leucosin, rather than starch, which is characteristic of other groups.

60. (B) Rhodophyta
Rhodophyta exhibit some of the most complex sexual reproductive cycles among algae. They develop specialized structures, including the female carpogonium and the male antheridium. Following fertilization, they undergo unique post-fertilization developments that lead to the formation of a carposporophyte phase. This phase produces carpospores, which eventually germinate to continue the life cycle, illustrating a highly sophisticated and multi-stage reproductive strategy.

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61. (C) They can grow on artificial nutrient media.
Viruses are unique biological entities that function as obligate intracellular parasites, meaning they can only replicate inside a living host cell. They are small enough to pass through filters that retain bacteria and can even be crystallized like pure chemicals. However, because they lack their own metabolic machinery and ribosomes, they cannot grow on artificial nutrient media like agar or broth.

62. (A) The phase where no infective virions are detectable.
In the context of the bacteriophage lytic cycle, the eclipse period is a specific phase that occurs immediately after the viral genome enters the host cell. During this time, the virus is actively synthesizing its components using the host's machinery, but no fully assembled, infectious virions are yet present. Consequently, if the host cell is ruptured, no infective particles can be recovered.

63. (B) 1 and 2 only
Rickettsia and Chlamydia are specialized groups of bacteria that function as obligate intracellular parasites, requiring a living host cell for survival. Unlike viruses, they possess their own metabolic enzymes, ribosomes, and cell walls, and they contain both DNA and RNA. While they share parasitic lifestyles, they are typically transmitted through specific vectors or direct contact, rather than the fecal-oral route common.

64. (C) A virion has a protein coat, while a viroid does not.
A virion is a complete, infectious virus particle that consists of a nucleic acid core, either DNA or RNA, protected by a protein coat called a capsid. In contrast, a viroid is a much simpler and smaller infectious agent. It consists entirely of a short, circular, single-stranded RNA molecule and lacks any form of protein coat or protective encapsulation.

65. (B) Extreme halophile
Organisms that thrive in environments with exceptionally high salt concentrations, such as the Dead Sea or Great Salt Lake, are known as extreme halophiles. They belong to the domain Archaea and possess specialized physiological adaptations to maintain cellular integrity and function under osmotic stress. These adaptations include unique cell membrane lipids and proteins that are stable and active only in highly saline conditions.

66. (A) 4, 5, 3, 1, 2
The parasexual cycle in fungi involves a series of genetic events that lead to recombination without a standard sexual cycle. It begins with plasmogamy, the fusion of cytoplasm, followed by karyogamy to form a diploid nucleus. Subsequent steps include the formation of a stable diploid lineage, mitotic recombination to shuffle genes, and finally haploidization, where chromosomes are gradually lost to return to haploidy.

67. (A) Bacilli
Bacteria are often classified based on their characteristic shapes. The term 'bacilli' is used to describe bacteria that are rod-shaped. Other common forms include 'cocci' for spherical bacteria, 'spirilla' for spiral-shaped ones, and 'vibrio' for those shaped like a comma. These morphological distinctions are fundamental to bacterial identification and taxonomy in microbiology, reflecting the structural organization of their cell walls.

68. (C) Phytophthora infestans - Late blight of potato
Late blight of potato is a devastating plant disease caused by the oomycete Phytophthora infestans. It is famous for causing the Irish Potato Famine in the mid-19th century. The pathogen attacks the leaves and tubers of potato plants, leading to rapid decay and crop loss. Other examples of fungal diseases include wheat rust caused by Puccinia and loose smut of wheat caused by Ustilago.

69. (A) Performs photosynthesis to produce carbohydrates.
In a lichen symbiosis, the phycobiont is the photosynthetic partner, which can be either a green alga or a cyanobacterium. Its primary role is to capture light energy and perform photosynthesis to produce carbohydrates. These organic nutrients are then shared with the fungal partner, the mycobiont. This energy production is essential for the growth and survival of the entire lichen thallus.

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70. (C) Statement I is true, but Statement II is false.
Brown algae, such as kelps, exhibit a high degree of thallus differentiation, often featuring a holdfast for attachment, a stem-like stipe, and leaf-like fronds. However, despite this outward complexity, they do not possess true roots, stems, or leaves with vascular tissues like higher plants. Red algae generally show simpler thallus structures and lack the specialized tissue differentiation seen in brown algae.

71. (B) Phaeophyta and Bacillariophyta
Fucoxanthin is a specialized xanthophyll pigment that imparts a characteristic brown or olive-green color to certain algal groups. It is found in abundance in the Phaeophyta, also known as brown algae, and in the Bacillariophyta, which are the diatoms. This pigment is highly efficient at absorbing blue-green light, which is particularly useful for photosynthesis in the marine environments where these organisms often thrive.

72. (A) Both A and R are true and R is the correct explanation of A.
Many species of cyanobacteria are known for their remarkable ability to survive in harsh or fluctuating environmental conditions. This resilience is largely due to their capacity to form akinetes, which are thick-walled, non-motile resting spores. Akinetes are packed with reserve food materials and can remain dormant for long periods, allowing the organism to germinate and resume growth when favorable conditions return.

73. (D) Silica
The cell wall of a diatom, known as a frustule, is a unique biological structure composed of two overlapping halves that fit together like a petri dish. This wall is primarily made of silica, specifically opaline or hydrated silicon dioxide. The indestructible nature of silica allows these intricate walls to be preserved after the death of the organism, leading to vast geological deposits.

74. (D) Basidiomycotina
Mushrooms are the prominent fruiting bodies of fungi belonging to the group Basidiomycotina. These structures, known as basidiocarps, typically feature gills or pores on their underside. Within these gills, specialized club-shaped cells called basidia produce sexual spores known as basidiospores. This group also includes other well-known fungi like puffballs, shelf fungi, and plant pathogens such as rusts and smuts.

75. (A) Absorptive chemoheterotrophic
Fungi are classified as absorptive chemoheterotrophs because of their unique way of obtaining nutrients. They do not perform photosynthesis or ingest whole food particles. Instead, they secrete powerful digestive enzymes into their surrounding organic substrate to break down complex molecules into simpler forms. These small nutrients are then absorbed directly through the fungal cell walls and membranes to support growth and reproduction.

76. (B) P-2, Q-4, R-1, S-3
Bacteria exchange genetic material through several specialized processes. Transformation involves the direct uptake of naked DNA from the surrounding environment. Conjugation requires physical contact between two cells, usually mediated by a pilus, to transfer plasmids. Transduction occurs when a bacteriophage virus accidentally carries bacterial genes from one host to another. In contrast, binary fission is a method of asexual reproduction, not recombination.

77. (D) Tuberculosis
Tobacco mosaic, influenza, and polio are all well-known diseases caused by various types of viruses. These pathogens consist of genetic material encased in protein. However, tuberculosis is a bacterial disease caused by the bacterium Mycobacterium tuberculosis. It primarily affects the lungs and is transmitted through respiratory droplets, illustrating the fundamental difference between viral and bacterial infections in human populations.

78. (A) The fungal partner in a lichen.
The term 'mycobiont' refers specifically to the fungal partner in a lichen symbiosis. This fungal component typically belongs to the Ascomycota and provides the overall structural framework of the lichen. It protects the photosynthetic partner, or phycobiont, from harsh environmental conditions and absorbs water and minerals from the substrate. This complex relationship allows lichens to thrive in extreme habitats worldwide.

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79. (C) Rhodophyta
Rhodophyta, or red algae, are predominantly marine organisms often found in deep-water habitats. Their characteristic red color comes from pigments like phycoerythrin, which are highly effective at absorbing the blue and green light that penetrates to great depths in the ocean. This adaptation allows red algae to perform photosynthesis and thrive in environments where other photosynthetic organisms cannot survive.

80. (A) All mycorrhizal associations are pathogenic to plants.
Fungi play diverse and often beneficial roles in human life and industry. Penicillium is a vital source of life-saving antibiotics, while Saccharomyces yeast is essential for fermentation in baking and brewing. Many mushrooms, such as Agaricus, are edible and highly nutritious. Mycorrhizal associations are generally mutualistic, providing essential nutrients to plants, rather than being pathogenic as they benefit both partners.

81. (C) Virusoid
A virusoid is a type of infectious agent consisting of a small, circular, single-stranded RNA molecule. Unlike viroids, which can replicate on their own, virusoids are dependent on a helper virus for both replication and the provision of a protein coat. The virusoid RNA is packaged within the capsid of the helper virus, which facilitates its transmission into host cells.

82. (B) Cytoplasm
Plasmogamy is the initial stage of sexual reproduction in fungi, involving the fusion of the cytoplasm from two compatible parent cells. This process brings two different haploid nuclei into a single cell, creating a dikaryotic or heterokaryotic state. However, the nuclei themselves do not immediately fuse; that occurs in a later stage called karyogamy, which finally results in a diploid zygote.

83. (C) Contain chlorophylls a and b, similar to land plants.
Prochlorophyta are significant in evolutionary biology because they are prokaryotes that possess both chlorophyll a and chlorophyll b. This specific combination of pigments is characteristic of green algae and land plants but is absent in most other cyanobacteria. Studying these organisms provides valuable insights into the possible evolutionary origins of chloroplasts in eukaryotic cells through the process of endosymbiosis.

84. (B) 2 and 3 only
Controlling viral diseases requires specific medical strategies. While antibiotics are ineffective against viruses, vaccination is a powerful tool that trains the immune system to recognize and attack specific viral pathogens. Additionally, antiviral drugs are designed to interfere with viral replication by inhibiting essential enzymes. Combining these methods is crucial for managing viral outbreaks and protecting public health on a global scale.

85. (A) Archaebacteria have ether-linked lipids in their cell membranes.
Archaebacteria are fundamentally different from Eubacteria due to their unique cell membrane chemistry. Their membranes contain ether-linked lipids with branched hydrocarbon chains, providing greater stability in extreme conditions. In contrast, Eubacteria possess ester-linked lipids. While both are prokaryotic and lack a nucleus, this molecular distinction in membrane structure is a primary criterion for classifying them into separate evolutionary domains.

86. (B) Foliose
Lichens are categorized by their growth forms. A foliose lichen is characterized by a leafy, flattened thallus that shows a distinct upper and lower surface. These lichens are typically loosely attached to their substrate, such as tree bark or rocks, by root-like structures called rhizines. This growth form distinguishes them from crusty, tightly attached crustose lichens or shrub-like fruticose lichens.

87. (C) Kuru
Kuru is a rare and fatal neurodegenerative disease that was primarily found among the Fore people of Papua New Guinea. It is caused by prions, which are misfolded infectious proteins that trigger abnormal folding of normal proteins in the brain. This leads to progressive neurological decline and death. Other well-known prion diseases include Creutzfeldt-Jakob disease and bovine spongiform encephalopathy, or "mad cow disease."

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88. (D) Starch
Members of the Chlorophyta, or green algae, are characterized by several plant-like features. They possess chlorophylls a and b as their primary photosynthetic pigments and store their reserve energy in the form of starch. This starch is typically deposited within chloroplasts, often around a specialized proteinaceous structure called a pyrenoid. These traits reflect their close evolutionary relationship with terrestrial plants.

89. (C) Deuteromycotina
Fungi that possess septate hyphae and produce asexual spores called conidia, but for which no sexual stage has been observed, are classified under Deuteromycotina. This group, also known as "Fungi Imperfecti," serves as a taxonomic repository for such organisms. Many members are eventually moved to other divisions, like Ascomycotina, once their sexual reproductive phase is discovered and described by mycologists.

90. (A) Can only grow and reproduce on a living host.
An obligate parasite, such as the fungus Puccinia graminis that causes wheat rust, is an organism that can only complete its life cycle and reproduce on a living host. These pathogens have evolved highly specialized relationships with their hosts and cannot be grown on non-living laboratory media. They derive all their necessary nutrients from the living tissues of their specific host.

91. (D) A rigid rod-like structure with helical capsomeres.
The Tobacco Mosaic Virus is characterized by a rigid, rod-like ultra-structure. This architecture consists of a single-stranded RNA genome that is helically coiled within a protective protein shell. This shell, or capsid, is made of numerous identical protein subunits called capsomeres arranged in a helical pattern. This simple yet highly efficient design protects the viral genetic material during transmission between hosts.

92. (B) Transduction
Transduction is a process of horizontal gene transfer in bacteria mediated by bacteriophages. During the viral replication cycle, a phage may accidentally package a segment of the host bacterium's DNA into its own capsid. When this phage subsequently infects another bacterium, it injects the donor DNA into the new recipient cell. This mechanism is a significant driver of genetic diversity in populations.

93. (C) Statement I is true, but Statement II is false.
Actinomycetes are true bacteria that are notable for their filamentous, branching growth pattern, which superficially resembles fungal mycelia. However, they are strictly prokaryotic in their cellular organization. One key difference from fungi is the composition of their cell walls, which contain peptidoglycan, a characteristic of bacteria, rather than the chitin typically found in fungal cell walls. They are major sources of antibiotics.

94. (D) Ascocarp
An ascocarp is the complex fruiting body produced by many fungi in the division Ascomycotina. It is formed during the sexual phase of the life cycle and houses the asci, which are sac-like structures where ascospores are developed. Ascocarps can take various shapes, such as cup-shaped apothecia or flask-shaped perithecia, and are essential for the protection and dispersal of sexual spores.

95. (A) Presence or absence of mitochondria
In phycology, the major classification of algae relies on biochemical and structural features. Key criteria include the specific types of photosynthetic pigments, the chemical nature of reserve food materials, and the organization of the thallus. While the presence of membrane-bound organelles is a general eukaryotic trait, the presence or absence of mitochondria is not used as a primary criterion to distinguish major algal.

96. (A) 2, 4, 3, 1
Algal thallus organization ranges from simple to highly complex forms. Unicellular Chlorophyta represent the simplest level, followed by colonial forms like Volvox. Charophyta exhibit more advanced structural differentiation with specialized reproductive organs. The most complex thallus structures are found in many Phaeophyta, such as kelps, which possess tissue-like organization and specialized parts like holdfasts, stipes, and fronds for various environmental functions.

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97. (C) Cyanobacterium
Cyanobacteria are prokaryotic organisms that perform oxygenic photosynthesis, using chlorophyll a to generate energy from light. They are also characterized by the presence of accessory pigments called phycobilins, which give them their distinctive blue-green color. Many species possess specialized cells called heterocysts for nitrogen fixation. These features combine to make them vital primary producers and nitrogen sources in many aquatic ecosystems.

98. (B) Toxin produced by a fungus.
A mycotoxin is a toxic chemical compound produced as a secondary metabolite by various types of fungi, particularly molds. These substances can contaminate agricultural crops and food products during growth, harvest, or storage. When ingested by humans or animals, mycotoxins can cause a range of adverse health effects, including acute poisoning, immune system suppression, and long-term risks such as liver cancer.

99. (C) Dinoflagellates
Red tides are natural phenomena caused by the rapid, dense growth of certain marine algae, most commonly dinoflagellates. These blooms can discolor the water and produce potent toxins that accumulate in shellfish and are lethal to fish and marine mammals. Human health can also be threatened through the consumption of contaminated seafood or by inhaling aerosolized toxins near the coastline.

100. (B) Phaeophyta - Starch as reserve food
Algal groups are distinguished by their specific storage molecules. Chlorophyta utilize starch, while Rhodophyta use floridean starch. Bacillariophyta store chrysolaminarin and oils. However, Phaeophyta, or brown algae, do not store starch. Instead, they primarily use laminarin, a complex carbohydrate, and the sugar alcohol mannitol as their main reserve food materials to survive and grow in their marine environments.

101. (A) Both A and R are true and R is the correct explanation of A.
Viroids are small, circular, single-stranded RNA molecules that are significant plant pathogens. Unlike viruses, they lack a protein coat. They cause disease by interfering with the host plant's normal gene expression and metabolic pathways. By hijacking cellular machinery to replicate, they disrupt the plant's physiological balance, leading to symptoms like stunting, leaf distortion, and reduced crop yields in various species.

102. (D) A wall-less prokaryote bounded by a plasma membrane.
Mycoplasmas are unique prokaryotic organisms characterized by the complete absence of a rigid cell wall. They are bounded only by a flexible plasma membrane, which often contains sterols for added stability. This wall-less nature makes them pleomorphic, meaning they can take on many different shapes. It also renders them naturally resistant to antibiotics that function by inhibiting bacterial cell wall synthesis.

103. (B) Zygospore
In the life cycle of Zygomycotina fungi like Rhizopus, sexual reproduction involves the fusion of specialized hyphal tips called gametangia. This process results in the formation of a thick-walled, highly resistant resting spore known as a zygospore. The zygospore is capable of surviving harsh environmental conditions, such as extreme temperatures or desiccation, and will germinate when favorable conditions return to support growth.

104. (A) P-2, Q-4, R-1, S-3
Fungi utilize diverse reproductive and genetic strategies. Heterokaryosis involves the coexistence of genetically distinct nuclei within a single cytoplasm. Heterothallism requires two compatible mating types for sexual reproduction, while homothallism allows a single individual to be self-fertile. Parasexuality provides a mechanism for genetic recombination through mitotic processes and chromosome loss, bypassing the traditional sexual cycle and the process of meiosis entirely.

105. (C) Mastigomycotina
Downy mildews, such as those that affect grapes and other crops, are caused by oomycetes, which are classified within the group Mastigomycotina. These organisms are characterized by the production of motile zoospores and are often found in moist environments. They are significant plant pathogens that can cause widespread

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agricultural damage by infecting leaves, stems, and fruits under humid and cool conditions.

106. (D) Chlorella
Chlorella is a genus of single-celled green algae that is widely used as a model organism in biological research. It is highly valued for its rapid growth rate and high nutritional content, making it a potential food source and dietary supplement. Additionally, Chlorella has been extensively studied for its ability to perform efficient photosynthesis and its potential applications in biotechnology.

107. (A) Rhodophyta and Cyanobacteria
Phycobilisomes are specialized light-harvesting protein complexes found in both Rhodophyta and Cyanobacteria. These structures contain accessory pigments called phycobilins, specifically phycoerythrin and phycocyanin. These pigments allow the organisms to efficiently absorb blue-green light, which is particularly useful for red algae living in deep marine environments and for cyanobacteria in various habitats where other light wavelengths may be limited or unavailable.

108. (C) 2 and 3 only
While some bacteria are pathogenic, many are beneficial or neutral. Archaebacteria are well-known for inhabiting extreme environments like hot springs and salt lakes. Cyanobacteria are ecologically vital because they perform oxygenic photosynthesis, releasing oxygen into the atmosphere as a byproduct. This process significantly contributed to the development of Earth's oxygen-rich atmosphere and supports diverse life forms in various aquatic and terrestrial.

109. (C) It builds a DNA copy from the viral RNA template.
Reverse transcriptase is a critical enzyme used by retroviruses, such as HIV, to replicate their genetic material. Once the virus enters a host cell, this enzyme uses the viral RNA as a template to synthesize a complementary DNA copy. This viral DNA can then be integrated into the host's own genome, allowing the virus to persist and direct the production of progeny.

110. (A) Spirogyra
Spirogyra is a common genus of green algae characterized by a filamentous, unbranched thallus. It consists of long chains of cylindrical cells arranged end-to-end. A distinguishing feature of this alga is its spiral-shaped chloroplasts, which are easily visible under a microscope. Spirogyra is typically found in freshwater environments, where it can form dense, slippery mats often referred to as "pond scum."

111. (D) A lipid envelope derived from the host.
A typical T-even bacteriophage has a complex, non-enveloped structure. It consists of an icosahedral protein head that contains the DNA genome, a contractile tail sheath, and tail fibers for host recognition and attachment. Unlike many animal viruses, these bacteriophages do not possess a lipid envelope derived from the host cell membrane, as they typically infect bacteria with rigid cell walls.

112. (B) Pioneer oxygenic photosynthesizers and nitrogen fixers.
Cyanobacteria are of immense biological importance because they were the first organisms to perform oxygenic photosynthesis. This evolutionary breakthrough led to the oxygenation of Earth's atmosphere, enabling the rise of aerobic life. Additionally, many cyanobacteria are capable of fixing atmospheric nitrogen, making them essential primary producers and nutrient recyclers in aquatic and terrestrial ecosystems, supporting diverse communities and global nutrient cycles.

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113. (A) Both Statement I and Statement II are true.
The fruiting body of a mushroom is scientifically known as a basidiocarp. This complex structure is entirely composed of dikaryotic hyphae, where each cell contains two genetically distinct haploid nuclei. These hyphae are organized into specialized tissues, such as the gills, where the nuclei eventually fuse to form diploid cells that undergo meiosis to produce basidiospores for the next generation.

114. (D) They appear to lack any nucleic acid (DNA or RNA).
Prions are unique among infectious agents because they appear to be composed entirely of protein and completely lack any nucleic acid,

such as DNA or RNA. All other known pathogens, including viruses, bacteria, and viroids, rely on genetic material to replicate. Prions replicate by inducing normal cellular proteins to misfold into the infectious, disease-causing form, leading to progressive neurological damage.

115. (A) Cell wall
The Gram stain is a fundamental microbiological technique used to categorize bacteria into two major groups: Gram-positive and Gram-negative. This differentiation is based on the structural and chemical composition of the bacterial cell wall. Gram-positive bacteria have a thick layer of peptidoglycan, while Gram-negative bacteria have a thinner layer and an outer membrane. This distinction is critical for diagnosis and antibiotic selection.

116. (B) Chlorophyta
Chlorophyta, or green algae, are characterized by several features that they share with terrestrial plants. They possess chlorophyll a and b as their primary photosynthetic pigments and store their reserve energy as starch. Additionally, their cell walls are typically composed of cellulose. These biochemical similarities provide strong evidence for the evolutionary link between green algae and the higher plant kingdom.

117. (B) Both partners exchange essential nutrients and water.
The symbiotic relationship in mycorrhiza is mutualistic because it provides significant benefits to both the plant and the fungus. The fungal hyphae extend into the soil, drastically increasing the root system's ability to absorb water and essential minerals, particularly phosphorus. In exchange, the plant provides the fungus with organic nutrients, primarily carbohydrates produced during photosynthesis, which the fungus needs to survive.

118. (A) Fungi are eukaryotic, and can be unicellular (yeasts) or multicellular (molds).
Fungi are eukaryotic organisms that exhibit a range of cellular organizations. They can be unicellular, such as yeasts that reproduce by budding, or multicellular, forming a network of thread-like hyphae as seen in molds and mushrooms. Regardless of their size or complexity, all fungi possess membrane-bound organelles, including a nucleus, and have cell walls typically composed of the polysaccharide chitin.

119. (C) Basidiomycetes
Smut diseases in crops like wheat are caused by fungi belonging to the class Basidiomycetes, particularly the genus Ustilago. These pathogens are characterized by the production of dark, powdery masses of teliospores, which often replace the host's reproductive organs or seeds. This group of fungi is noted for its complex life cycles and its significant economic impact on global agricultural productivity.

120. (D) Two dissimilar flagella, one tinsel and one whiplash.
Heterokont flagellation is a taxonomic feature found in certain algal groups where an organism possesses two dissimilar flagella. Typically, one flagellum is of the tinsel type, covered with fine hairs or mastigonemes, while the other is a smooth whiplash flagellum. This arrangement is characteristic of the Stramenopiles, including brown algae and diatoms, and plays a vital role in motility and.

121. (A) Both A and R are true and R is the correct explanation of A.
Lichens are highly sensitive to air pollution, particularly sulfur dioxide, because they lack a protective cuticle and efficiently absorb water and minerals directly from the atmosphere. Consequently, they also accumulate pollutants, which can reach toxic levels and inhibit their growth. This sensitivity makes lichens valuable bioindicators, as their presence or absence can provide information about the air quality in an.

122. (B) It often carries genes for antibiotic resistance or other special functions.
Plasmids are small, circular, extrachromosomal DNA molecules that occur naturally in many bacterial cells. While they do not carry genes essential for basic survival, they often provide selective advantages in specific environments. For instance, plasmids frequently carry genes for antibiotic resistance, toxin production, or the ability to metabolize unusual substances. These traits can be transferred between bacteria through the process of.

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123. (C) Their chlorophylls are masked by an abundance of xanthophyll pigments.
Xanthophyta, or yellow-green algae, owe their distinctive color to a high concentration of xanthophyll pigments that mask their chlorophyll. They typically contain chlorophyll a and c but lack the fucoxanthin found in brown algae. These organisms are found in various aquatic habitats and store their reserve food as oils or leucosin. Their unique pigment profile and storage products distinguish them from.

124. (C) Fungi
The Kingdom Fungi is defined by a set of distinct biological characteristics. Its members are eukaryotic and possess cell walls made primarily of chitin. They are characterized by an absorptive heterotrophic mode of nutrition, secreting enzymes to break down organic matter externally. Furthermore, they store their reserve energy as glycogen, similar to animals but unlike plants, which use starch as storage.

125. (A) Plasmogamy
Fungi reproduce asexually through various mechanisms that do not involve the fusion of nuclei or specialized sexual structures. These methods include budding, fragmentation of the mycelium, and the production of numerous asexual spores like conidia. Plasmogamy, however, is the first step of sexual reproduction, involving the fusion of cytoplasm from two compatible mating types to bring distinct nuclei together.

126. (A) P-4, Q-1, R-3, S-2
Algae are a source of many important commercial products. Agar is extracted from red algae like Gelidium, while alginic acid is obtained from brown algae. Carrageenan is another product from red algae, such as Chondrus. Diatomaceous earth consists of the fossilized silica remains of diatoms. These materials have wide applications in industries ranging from food and pharmaceuticals to filtration and environmental engineering.

127. (B) Phaeophyta
Among the various algal groups, the Phaeophyta, or brown algae, exhibit the most advanced and complex thallus structures. Many species, particularly large kelps, show a high degree of tissue differentiation, featuring specialized parts like a holdfast for anchorage, a stem-like stipe, and leaf-like fronds. This level of organization is much more sophisticated than the simple unicellular or filamentous forms seen elsewhere.

128. (C) Bacteriophage
A bacteriophage, often simply called a phage, is a specialized virus that exclusively infects and replicates within bacterial cells. These viruses are composed of a protein capsid protecting their genetic material. They attach to the bacterial surface and inject their DNA or RNA to hijack the host's machinery. Bacteriophages are highly specific, often targeting only a few strains of a single bacterial species.

129. (D) Contributing to aquatic production and atmospheric oxygen.
Cyanobacteria play a fundamental biological role as primary producers in aquatic ecosystems. By performing oxygenic photosynthesis, they contribute significantly to global carbon fixation and the production of atmospheric oxygen. Many species are also capable of fixing atmospheric nitrogen, which provides a vital nutrient source for other organisms. These processes are essential for maintaining the balance of life in many diverse aquatic environments.

130. (A) Archaebacterium
An organism whose cell wall contains pseudo-peptidoglycan rather than the true peptidoglycan found in Eubacteria is classified as an Archaebacterium. This molecular difference is a key feature of the domain Archaea, which also includes unique membrane lipids and genetic sequences. These adaptations often allow Archaebacteria to thrive in extreme environments that are inhospitable to most other life forms on Earth.

131. (B) Eight haploid ascospores.
The ascus is the characteristic sac-like reproductive structure of the division Ascomycotina. Following sexual fusion and meiosis, a subsequent mitotic division typically results in the formation of eight haploid ascospores within each ascus. These spores are eventually released for dispersal. This internal development of sexual spores is a defining feature that distinguishes Ascomycetes from other fungal groups like Basidiomycetes.

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132. (C) Smut
Smut is a type of plant disease caused by certain fungi, particularly those in the genus Ustilago. These pathogens typically infect the reproductive organs of the host plant, such as the ovaries of cereal grains. The fungus replaces the developing seeds with a mass of dark, powdery teliospores. This characteristic symptom is how the disease gets its common name in agricultural contexts.

133. (D) Statement I is false, but Statement II is true.
While the vast majority of algae are photosynthetic autotrophs, there are several groups that have secondarily lost their pigments and become heterotrophic. These organisms obtain their energy by absorbing organic compounds from their environment. Despite this shift in nutritional mode, they are still classified as algae based on their structural features, life cycles, and evolutionary relationships with photosynthetic species in their respective groups.

134. (D) Measles
Many common and serious human diseases are caused by viral pathogens. Measles, for example, is a highly contagious respiratory infection characterized by a distinctive rash and fever. Other examples include influenza, polio, and smallpox. In contrast, diseases like tetanus and cholera are caused by bacteria, while malaria is caused by a protozoan parasite, highlighting the diverse nature of infectious agents in humans.

135. (A) Nitrogen fixation
Heterocysts are specialized, thick-walled cells in certain filamentous cyanobacteria that function as the primary site for nitrogen fixation. The thickened walls help protect the enzyme nitrogenase from atmospheric oxygen, which would otherwise inhibit its activity. This allows the cyanobacteria to convert nitrogen gas into a usable form like ammonia, even in oxygen-rich aquatic or terrestrial environments where they typically reside.

136. (D) 1, 2 and 3
Fungi exhibit diverse nutritional strategies, all of which are heterotrophic. Saprophytic fungi obtain their energy by decomposing dead organic matter, playing a vital role in nutrient recycling. Parasitic fungi derive nutrients from living host organisms, often causing disease. Symbiotic fungi live in mutually beneficial partnerships, such as mycorrhizae with plant roots or lichens with algae, where both organisms benefit from the association.

137. (B) Rhodophyta
Floridean starch is a specialized storage polysaccharide that is characteristic of the algal division Rhodophyta, or red algae. It is chemically similar to the amylopectin component of terrestrial plant starch but is stored as granules in the cytoplasm rather than within chloroplasts. This unique storage molecule serves as a critical energy reserve for red algae in their diverse marine and freshwater habitats.

138. (C) Conjugation
Conjugation is a process of genetic transfer in bacteria that requires direct physical contact between two living cells. Often mediated by a specialized structure called a sex pilus, genetic material—usually a plasmid—is transferred from a donor cell to a recipient. This mechanism allows for the rapid spread of traits such as antibiotic resistance through a bacterial population, significantly impacting their evolutionary success.

139. (D) Mastigomycotina
Fungi that produce motile asexual spores called zoospores are classified within the division Mastigomycotina. These spores are equipped with flagella, allowing them to swim through liquid environments to colonize new substrates or infect hosts. This characteristic aquatic adaptation is a key feature that distinguishes them from other major fungal groups like Ascomycotina or Basidiomycotina, which produce non-motile spores for dispersal.

140. (A) 1, 2, 3, 4
Biological classification follows a hierarchical system of taxonomic ranks. In descending order of inclusivity, the major ranks are Kingdom, Division (in botany and phycology) or Phylum (in zoology), Class, Order, Family, Genus, and Species. This structured organization allows scientists to group organisms based on shared characteristics and evolutionary relationships, providing a universal framework for identifying and studying the diversity of life.

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141. (B) Their lack of a wall and pleomorphic nature.
Mycoplasmas are unique among prokaryotes because they lack a rigid cell wall, being enclosed only by a flexible plasma membrane. This structural absence makes them extremely pleomorphic, allowing them to change shape and squeeze through very small openings. Consequently, they can pass through filters that are designed to retain larger, more rigid bacteria, which is a critical factor in their study and detection.

142. (A) Both A and R are true and R is the correct explanation of A.
The parasexual cycle is a vital process in certain fungi for generating genetic diversity without a conventional sexual cycle. It involves the occasional fusion of haploid nuclei in a heterokaryon, followed by mitotic crossing-over during cell division. A subsequent process of haploidization reassorts the genetic material, leading to new combinations of traits. This mechanism is particularly important for fungi that lack sexual.

143. (D) The nature of their sexual reproductive structures and spores.
The major classification of fungi into divisions such as Ascomycotina and Basidiomycotina is primarily based on the nature of their sexual reproductive structures and the type of sexual spores they produce. Ascomycetes are defined by asci and ascospores, while Basidiomycetes are characterized by basidia and basidiospores. These structural differences reflect fundamental evolutionary divergences in their life cycles and methods of reproduction.

144. (A) Normally acts as a saprophyte but can infect hosts.
A facultative parasite is an organism that normally lives as a saprophyte, decomposing dead organic matter, but has the ability to infect a living host under certain conditions. This flexibility allows the organism to survive in various environments. In contrast, an obligate parasite must have a living host to survive, illustrating the different strategies organisms use to obtain nutrients and ensure survival.

145. (B) Phycobilins
Phycobilins are a group of accessory photosynthetic pigments found in red algae and cyanobacteria. They include phycoerythrin, which is red, and phycocyanin, which is blue. These pigments are organized into protein complexes called phycobilisomes and are particularly efficient at capturing light wavelengths that chlorophyll a cannot absorb well. This adaptation is crucial for organisms living in deep-water or shaded aquatic environments.

146. (C) A bite from an arthropod vector like a tick.
Rickettsia are small, obligate intracellular bacteria that are typically transmitted to humans through the bites of arthropod vectors, such as ticks, fleas, or lice. Once inside the body, they infect the lining of blood vessels, leading to diseases like Rocky Mountain spotted fever or typhus. This mode of transmission distinguishes them from many other bacterial pathogens that spread through ingestion or inhalation.

147. (D) They are all marine, deep-water algae.
Charophyta are a specialized group of green algae that exhibit complex thallus structures and are widely considered the closest relatives of land plants. While they show a high degree of differentiation and commonly reproduce via oogamy, they are primarily freshwater organisms. They are typically found in ponds, lakes, and streams, rather than being strictly marine, deep-water algae as some other groups.

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148. (A) Fruticose
Lichens with a shrub-like, highly branched thallus that is typically attached to the substrate at a single point are classified as fruticose. These lichens often grow upright or hang down from tree branches. Their structure provides a large surface area for gas exchange and light absorption. This growth form is distinct from the flat, leafy foliose lichens or the tightly attached crustose types.

149. (C) Viral replication is dependent on the host cell's metabolic machinery.
Viral replication is fundamentally different from that of cellular organisms because viruses are obligate intracellular parasites. They lack their own ribosomes and metabolic machinery and therefore cannot replicate independently. Instead, they must infect a suitable host cell and hijack its

energy, enzymes, and structural components to synthesize and assemble new viral particles. This total dependency is a defining characteristic of all viruses.

150. (B) P-3, Q-4, R-1, S-2
Fungal divisions are distinguished by their unique structural and reproductive characteristics. Mastigomycotina produce motile zoospores, while Zygomycotina are noted for aseptate hyphae and zygospores. Ascomycotina are characterized by the production of ascospores within an ascus. Basidiomycotina produce basidiospores on a specialized structure called a basidium. These traits are fundamental to the classification and study of the kingdom Fungi and its diverse members.

151. (B) Escherichia coli
Prokaryotic organisms are characterized by a simple cellular structure that lacks a membrane-bound nucleus and other organelles. Escherichia coli is a classic example of a bacterium and is strictly prokaryotic. In contrast, yeast, Amoeba, and Chlamydomonas are all eukaryotic organisms, as they possess defined nuclei and complex internal membrane systems. Understanding this fundamental distinction is essential for identifying different types of microorganisms.

152. (C) Ascomycotina and Basidiomycotina
A prominent dikaryotic phase, where each cell contains two genetically distinct haploid nuclei (n+n), is a characteristic feature of the life cycles in both Ascomycotina and Basidiomycotina. This stage occurs after plasmogamy but before karyogamy. In these groups, the dikaryotic state can persist for a significant period, often forming the majority of the complex fruiting body structure before final nuclear fusion.

153. (D) Spherical or polyhedral
An icosahedral capsid is a common structural form for many viruses. It consists of a protein shell made of twenty triangular faces, which gives the virus a roughly spherical or polyhedral appearance under a microscope. This geometric shape is highly efficient for enclosing the viral genome and is found in a wide variety of viruses infecting animals, plants, and even bacteria.

154. (A) Viral DNA integrated into a bacterial chromosome.
A prophage is the state of a bacteriophage's genetic material when it has integrated into the chromosome of its bacterial host. This occurs during the lysogenic cycle, where the viral DNA remains dormant and is replicated along with the bacterial DNA during cell division. The prophage can later be induced to excise from the chromosome and enter a lytic cycle.

155. (B) Parenchymatous and sheet-like
Ulva, commonly known as sea lettuce, is a green alga with a distinctive parenchymatous thallus organization. Its body consists of a thin, sheet-like structure that is typically only two cell layers thick. This flat, leafy appearance allows for a large surface area for photosynthesis and nutrient absorption from the surrounding marine environment. Ulva is frequently found in intertidal zones along many coastlines.

156. (B) 2 and 3 only
Viroids are small, infectious agents that cause disease in many plant species. They are characterized by a genome consisting entirely of a naked, circular, single-stranded RNA molecule and completely lack a protein coat or capsid. Their genomes are much smaller than those of typical viruses. These unique properties distinguish them from other pathogens and illustrate the diversity of infectious agents in plants.

157. (D) Their sexual stage of reproduction is unknown or absent.
The name "Fungi Imperfecti" for the group Deuteromycotina reflects the fact that their life cycles are considered incomplete by researchers. These fungi are placed in this category because their sexual stage of reproduction has not been observed or is naturally absent. They primarily reproduce through asexual spores like conidia. Many are eventually reclassified once their sexual reproductive phase is finally discovered.

158. (A) Both Statement I and Statement II are true.
Algae are economically important for producing various hydrocolloids. Alginates, derived from brown algae, are widely used as stabilizers and thickeners in food and industrial products. Agar, extracted from red algae, is an essential component in microbiology for creating solid

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culture media. These substances highlight the practical utility of algal biochemicals in modern technology and industry, demonstrating their broad economic significance.

159. (A) Viroid
Potato spindle tuber disease is caused by a viroid, which is a small, circular, single-stranded RNA molecule without a protein coat. This pathogen disrupts the growth and development of the potato plant, leading to stunted growth and elongated, spindle-shaped tubers. It is one of the most well-studied examples of a viroid-caused disease, illustrating the significant impact these simple infectious agents can have.

160. (B) It creates genetic variation through recombination.
Sexual reproduction in fungi is biologically significant because it facilitates genetic recombination. By combining genetic material from two different parental mating types, the process creates new combinations of alleles in the offspring. This genetic variation is essential for the adaptation and evolution of fungal populations, allowing them to better survive changing environmental conditions and potential threats like fungicides or host immune responses.

161. (B) Presence of chlorophyll
Fungi are eukaryotic, heterotrophic organisms that possess cell walls made of chitin and store energy as glycogen. A defining characteristic that separates them from plants is the complete absence of chlorophyll. Because they cannot perform photosynthesis, they must obtain their organic nutrients by absorbing them from dead or living sources in their environment. This fundamental difference is key to their classification.

162. (A) Transformation
Transformation is a form of horizontal gene transfer in bacteria where a cell takes up naked DNA fragments from its surrounding environment. This DNA, often released by dead bacteria, can then be integrated into the recipient cell's chromosome. This process can provide the bacterium with new traits, such as antibiotic resistance, and is an important mechanism for genetic diversity in natural populations.

163. (B) Absorb blue-green light that penetrates to deeper water.
The unique pigment composition of Rhodophyta, including chlorophyll a and d along with phycobilins, allows them to absorb the blue-green light that penetrates to deeper water levels. This adaptation enables red algae to perform photosynthesis and thrive in marine environments at depths where other algal groups cannot survive. These pigments are essential for their ecological success in diverse ocean habitats.

164. (A) 2, 4, 1, 3
Following the entry of viral DNA into a host cell, the lysogenic cycle follows a specific sequence. First, the viral DNA integrates into the host chromosome to become a prophage. The host cell then lives and reproduces normally, with the prophage being copied during every cell division. Eventually, an induction event may occur, causing the prophage to excise and replicate.

165. (C) Chrysolaminarin and oils
Diatoms, which belong to the division Bacillariophyta, store their reserve photosynthetic energy in the form of chrysolaminarin and oils. Chrysolaminarin is a specialized polysaccharide, while the oils provide a dense energy source and can also help with buoyancy in aquatic environments. These storage molecules are distinct from the starch found in green algae and are a key characteristic of diatoms.

166. (B) The protein shell enclosing the nucleic acid.
The capsid of a virus is the protein shell that encloses and protects its nucleic acid genome. It is analogous in function to a protective container or envelope that shields its contents from the external environment. This protein structure is essential for maintaining the integrity of the viral genetic material and for facilitating the initial stages of infection in a suitable host cell.

167. (A) Both A and R are true and R is the correct explanation of A.
Endomycorrhizae, particularly arbuscular mycorrhizae, are extremely common symbiotic associations between fungi and plant roots. In this relationship, the fungal hyphae penetrate the cortical cells of the root and form highly branched structures called arbuscules. These arbuscules provide a large surface area for the efficient

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exchange of nutrients, such as phosphate from the fungus and carbohydrates from the plant host.

168. (A) Archaea
Organisms that are prokaryotic, lack peptidoglycan in their cell walls, and inhabit extreme environments like hot sulfur springs belong to the domain Archaea. These "extremophiles" have evolved unique molecular adaptations, such as ether-linked membrane lipids and specialized proteins, that allow them to function at temperatures and pH levels that would denature the cellular components of most other known life forms.

169. (C) Chromosomes carry essential genes, while plasmids carry non-essential genes.
The fundamental difference between a plasmid and the primary bacterial chromosome lies in the types of genes they carry. The chromosome contains essential genes necessary for basic cellular metabolism, growth, and reproduction. In contrast, plasmids carry non-essential genes that provide specialized advantages, such as antibiotic resistance or the ability to degrade specific toxins, which are not required under normal conditions.

170. (A) Cyanobacteria
Akinetes and hormogonia are specialized structures associated with the life cycles of various cyanobacteria. Akinetes are thick-walled resting spores that allow the organism to survive unfavorable environmental conditions through dormancy. Hormogonia are short, motile segments of filaments that break off from the parent colony to facilitate dispersal and asexual reproduction. These structures are essential for the persistence and spread of cyanobacteria.

171. (C) Mastigomycotina
Fungi with coenocytic hyphae that produce motile zoospores are classified within the group Mastigomycotina. These organisms are typically found in moist or aquatic environments where their flagellated spores can swim to find new substrates or hosts. This reproductive strategy distinguishes them from other major fungal groups like Zygomycotina, which also have coenocytic hyphae but produce non-motile spores for dispersal in the environment.

172. (B) Mutualistic symbiosis
The relationship between the fungus and the alga in a lichen is a classic example of mutualistic symbiosis. Both partners derive essential benefits from the association: the alga performs photosynthesis to provide carbohydrates, while the fungus provides structural protection, anchorage, and absorbs water and minerals. This partnership allows lichens to colonize and survive in some of Earth's most extreme environments.

173. (C) Predominantly marine, in cool coastal waters.
Phaeophyta, or brown algae, are predominantly marine organisms that are most common in cool coastal waters. They often form extensive underwater forests, such as kelp beds, which provide habitat and food for many other marine species. While some species can be found in other environments, their peak diversity and ecological importance are centered in these temperate and polar marine habitats.

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174. (D) Rhodophyta - Phycoerythrin
Algal groups are characterized by their specific combinations of photosynthetic pigments. Rhodophyta, or red algae, are noted for possessing phycoerythrin, which gives them their distinctive color and allows them to photosynthesize at great depths. In contrast, Chlorophyta have chlorophylls a and b, Phaeophyta contain fucoxanthin, and Bacillariophyta (diatoms) have chlorophyll a and c. These pigment profiles are fundamental taxonomic characters.

175. (A) A complete, infectious virus particle outside a host cell.
A virion is a complete, structurally intact, and infectious virus particle as it exists outside a host cell. It consists of the viral genome, either DNA or RNA, enclosed within a protective protein capsid, and sometimes an external lipid envelope. This extracellular form is the vehicle by which the virus is transmitted from one host cell to another to initiate infection.

176. (B) P-4, Q-1, R-2, S-3
Various microorganisms cause distinctive diseases in plants. Phytophthora infestans is responsible for late blight of potato, while Puccinia graminis tritici causes black stem rust of wheat. Ustilago tritici is the agent behind loose smut of wheat. Finally, the Tobacco Mosaic

Virus causes mosaic symptoms in tobacco plants. These examples illustrate the diversity of fungal and viral plant pathogens in agriculture.

177. (B) Prokaryotic cellular organization.
Both Archaebacteria and Eubacteria share the fundamental characteristic of prokaryotic cellular organization. This means they both lack a membrane-bound nucleus and other complex organelles such as mitochondria or chloroplasts. While they differ in many biochemical aspects, such as membrane lipid structure and cell wall composition, their simple, non-compartmentalized internal structure is a defining trait that unites them under the broader category.

178. (C) Basidiomycotina
Dolipore septa are a specialized and complex type of cross-wall found in the hyphae of many fungi within the division Basidiomycotina. These septa have a central pore surrounded by a barrel-shaped swelling and are often covered by a perforated membrane called a parenthesome. This structure regulates the movement of organelles and cytoplasm between adjacent cells, which is important for fungal growth.

179. (D) Prochlorophyta
An organism that is prokaryotic but possesses chlorophylls a and b, stores starch, and has a cellulose cell wall is classified as a Prochlorophyte. This unique combination of plant-like biochemical traits and bacterial cellular organization makes them an important group for studying the evolutionary history of photosynthesis and the possible origins of chloroplasts in eukaryotic plants and green algae species.

180. (A) Aspergillus
Aflatoxins are potent and dangerous mycotoxins produced by certain species of the fungal genus Aspergillus, most notably Aspergillus flavus. These toxins are often found as contaminants in agricultural products such as peanuts, corn, and tree nuts that have been stored under warm and humid conditions. Because aflatoxins are highly carcinogenic, their presence in the food supply is a major concern.

181. (A) 2 only
Prions are a unique class of infectious agents composed entirely of misfolded proteins and completely lack any nucleic acids like DNA or RNA. They cause various fatal neurodegenerative diseases by inducing normal proteins to also misfold. Prions are remarkably resistant to standard sterilization methods, including typical autoclaving procedures, which makes them a significant challenge for medical disinfection and public health safety.

182. (C) Fusion of two haploid nuclei to form a diploid nucleus.
Karyogamy is a critical step in the sexual life cycle of fungi, following the initial fusion of cytoplasm called plasmogamy. It is the process where two haploid nuclei within a dikaryotic cell finally fuse to form a single diploid nucleus or zygote. This diploid stage is usually brief and is immediately followed by meiosis, which produces recombinant haploid spores to restart.

183. (D) The fungal partner provides carbohydrates to the alga.
Lichens are complex symbiotic organisms where a fungus and a photosynthetic partner live together. While the fungal partner provides structural support, protection, and absorbs water and minerals, it does not provide carbohydrates to the alga. Instead, the alga (phycobiont) performs photosynthesis and provides the organic nutrients to the fungus (mycobiont). This fundamental exchange is the basis of their successful relationship.

184. (B) Frustules
The intricate and highly patterned cell walls of diatoms are known as frustules. These walls are primarily composed of opaline silica and consist of two overlapping halves called valves. The indestructible nature of these silica frustules means they are preserved in aquatic sediments after the diatom dies, eventually forming massive deposits of diatomaceous earth over millions of years of accumulation.

185. (D) Ascomycotina
Fungi that produce their sexual spores within a microscopic, sac-like structure called an ascus belong to the division Ascomycotina. Typically, each ascus contains exactly eight haploid

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ascospores, which are formed after a single round of meiosis and one subsequent mitotic division. This internal development of spores is a key characteristic that distinguishes this group from Basidiomycetes, which produce spores externally.

186. (A) The prevention of self-fertilization and promotion of outbreeding.
Heterothallism is a reproductive strategy in fungi that requires the presence of two compatible but genetically different mating types for sexual reproduction to occur. This mechanism is functionally important because it prevents self-fertilization and promotes outbreeding within the population. By ensuring that sexual fusion only happens between different individuals, heterothallism increases genetic diversity, which is essential for adaptation and evolutionary survival.

187. (A) Both Statement I and Statement II are true.
Mycorrhizal associations are highly beneficial to both the plant and the fungus. The plant benefits because the fungal hyphae extend into the soil, significantly increasing the surface area for the absorption of water and essential minerals like phosphorus. In return, the fungus benefits by obtaining energy-rich carbohydrates produced by the plant through photosynthesis. This mutual exchange is vital for the ecosystem's.

188. (C) Monera
In the five-kingdom classification system proposed by Robert Whittaker, all prokaryotic organisms are placed within the Kingdom Monera. This kingdom encompasses both Eubacteria and Archaebacteria. Members of Monera are characterized by their simple cellular structure, lacking a membrane-bound nucleus and other complex organelles. This broad grouping highlights the fundamental distinction between prokaryotic life and the various eukaryotic kingdoms like Protista.

189. (D) Absence of any flagellated stage in the life cycle.
A key characteristic of the algal division Rhodophyta, or red algae, is the complete absence of flagellated stages throughout their entire life cycle. Neither their vegetative cells nor their reproductive cells, such as gametes and spores, possess flagella. This is a unique trait among major algal groups and means that their dispersal and fertilization rely entirely on water currents and environment.

190. (B) A prion
Creutzfeldt-Jakob disease (CJD) is a rare and fatal neurodegenerative condition in humans. It is caused by prions, which are misfolded infectious proteins that trigger the abnormal folding of normal cellular proteins in the brain. This process leads to rapid brain damage and loss of function. CJD is part of a larger group of diseases called transmissible spongiform encephalopathies, which also include scrapie.

191. (C) Temperate phage
A bacteriophage that has the ability to integrate its genome into the host's chromosome and replicate along with it without causing immediate lysis is called a temperate phage. This process is known as the lysogenic cycle. The integrated viral DNA, called a prophage, can remain dormant for many generations until it is eventually induced to enter the lytic cycle and replicate.

192. (D) Production of citric acid by Aspergillus niger.
Fungi have many beneficial applications in human industry and medicine. A prominent example is the production of citric acid by the fungus Aspergillus niger, which is widely used as an additive in the food and beverage industries. Other beneficial roles include the production of antibiotics, the use of yeast in baking and brewing, and the recycling of nutrients through natural decomposition.

193. (A) Chlorophyll a
Chlorophyll a is the primary photosynthetic pigment found in all groups of algae as well as in cyanobacteria. It is responsible for capturing light energy and initiating the chemical reactions of photosynthesis. While different algal divisions possess various accessory pigments like chlorophyll b, c, or phycobilins to capture additional light wavelengths, chlorophyll a is the universal pigment required for the process.

194. (B) Obligate parasite
Puccinia is a genus of fungi that includes the species responsible for causing rust diseases in wheat and other crops. These fungi are classified as obligate parasites because they can only grow

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and reproduce on a living host plant. They have evolved highly specialized mechanisms to derive nutrients from the host's living tissues and cannot be cultivated on non-living laboratory culture media.

195. (C) Meiosis
Bacteria achieve genetic diversity through several horizontal gene transfer mechanisms, including conjugation, transformation, and transduction. However, meiosis is not found in bacteria. Meiosis is a specialized type of cell division that occurs only in eukaryotic organisms to produce haploid gametes for sexual reproduction. Bacteria primarily reproduce asexually through binary fission and rely on non-meiotic processes for genetic recombination and population variation.

196. (A) Both A and R are true and R is the correct explanation of A.
Bacteriophages typically exhibit a very narrow host range, often infecting only a single bacterial species or even specific strains. This high level of specificity is due to the attachment process, which requires precise interaction between proteins on the phage surface and specific receptor molecules on the bacterial cell wall. This lock-and-key mechanism ensures that the phage only infects compatible host cells.

197. (A) Thallus
The term 'thallus' refers to the entire vegetative body of an alga or a fungus that lacks differentiation into true roots, stems, and leaves. While some algae may have structures that superficially resemble these organs, such as holdfasts or leaf-like fronds, they do not possess the complex vascular tissues found in higher plants. This simple, relatively undifferentiated organization is a key characteristic.

198. (B) Red algae
Agar-agar is a commercially important gelatinous substance extracted from the cell walls of several genera of red algae, most notably Gelidium and Gracilaria. It is widely used in laboratory research as a solidifying agent for microbial culture media because it remains solid at incubation temperatures and is not easily broken down by most bacteria. Additionally, it has diverse applications in food.

199. (C) The proper nuclear distribution in daughter dikaryon cells.
A clamp connection is a specialized structure found in the dikaryotic hyphae of many Basidiomycetes. Its primary function is to ensure the proper distribution of nuclei during cell division. By forming a bridge-like connection, it allows one of the daughter nuclei to move into the new cell, ensuring that both resulting cells contain one nucleus from each of the two parents.

200. (D) Bacteria possess both DNA and RNA, while viruses possess either DNA or RNA.
A fundamental difference between viruses and bacteria lies in their genetic material and cellular organization. Bacteria are unicellular prokaryotic organisms that possess both DNA and RNA. In contrast, viruses are acellular entities that contain only one type of nucleic acid, either DNA or RNA, but never both simultaneously. This distinction reflects their different strategies for storing and expressing genetic information during replication.

201. (C) P-4, Q-1, R-2, S-3
Algal divisions are distinguished by the specific types of reserve food materials they store after photosynthesis. Chlorophyta store their energy as starch, while Phaeophyta utilize laminarin. Rhodophyta are characterized by the storage of floridean starch. Bacillariophyta, or diatoms, typically store their reserves as chrysolaminarin and oils. These diverse storage molecules are important biochemical markers used by phycologists for the scientific classification.

202. (A) Viral infections
Plant viruses cause a wide range of characteristic systemic symptoms as they multiply and spread through the host's tissues. Common indicators of viral infection include mosaic patterns on leaves, where areas of light and dark green appear, as well as leaf rolling, yellowing (chlorosis), and overall stunting of growth. These symptoms reflect the virus's disruption of the plant's normal physiological and developmental.

203. (B) Cyanobacteria
Cyanobacteria are prokaryotic organisms that perform oxygenic photosynthesis, using chlorophyll a as their primary pigment along with accessory phycobilins. A distinguishing

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feature of this group is the complete absence of flagella at all stages of their life cycle. These organisms are vital primary producers in aquatic environments and are notable for their ability to contribute significantly to atmospheric oxygen and nitrogen.

204. (C) Chitin
The cell wall of the vast majority of fungi is primarily composed of chitin, a tough and flexible polysaccharide. This material provides structural support and protection to the fungal cells, which are typically organized into hyphae. The presence of chitin is a key characteristic that distinguishes fungi from plants, whose cell walls are made of cellulose, and from bacteria with peptidoglycan.

205. (D) Lack septa and are multinucleate.
The term 'coenocytic' is used to describe fungal hyphae that lack internal cross-walls or septa. This results in a continuous cytoplasmic mass that contains multiple nuclei. Coenocytic organization is a characteristic feature of several fungal groups, including the Zygomycotina and some members of the Mastigomycotina. This structure allows for the rapid transport of materials and nutrients along the length of the.

206. (B) 1 and 3 only
Mycoplasmas are specialized prokaryotic organisms that are characterized by several unique features. They are the smallest known free-living cells and are distinguished by the complete absence of a cell wall. Because they lack a wall, they are naturally insensitive to antibiotics like penicillin that target cell wall synthesis. These organisms are pleomorphic and can cause various diseases in humans and animals.

207. (A) Plasmogamy → Karyogamy → Mitotic crossing over → Haploidization
The parasexual cycle in fungi follows a specific sequence of genetic events that lead to recombination without a traditional sexual cycle. The process begins with plasmogamy, the fusion of cytoplasm from two compatible mating types. This is followed by karyogamy, where the nuclei fuse to form a diploid cell. Subsequent events include mitotic crossing-over to shuffle genes and finally haploidization for recovery.

208. (C) Hyphae
The vegetative body of most fungi is composed of an extensive network of microscopic, thread-like filaments called hyphae. These structures grow from their tips and branch out to explore and colonize their substrate. A mass of interconnected hyphae is collectively known as a mycelium. Hyphae are responsible for nutrient absorption and secrete enzymes that break down complex organic matter in the environment.

209. (B) Similarities in cell division, sperm structure, and chlorophylls.
Charophyta are widely considered the closest living relatives to the ancestors of terrestrial plants. This evolutionary link is supported by several shared characteristics, including similar mechanisms of cell division (such as the formation of a phragmoplast), similarities in sperm cell structure, and the presence of the same types of chlorophylls (a and b). These shared traits provide compelling evidence for land plants.

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210. (A) Both Statement I and Statement II are true.
Prions are specialized infectious agents that are responsible for a variety of fatal neurodegenerative diseases, such as scrapie in sheep and Creutzfeldt-Jakob disease in humans. They are unique among pathogens because they are composed entirely of a misfolded protein and completely lack any nucleic acid core. Prions replicate by inducing normal cellular proteins to change their shape into the infectious form.

211. (B) The lytic cycle causes host death, while lysogeny allows replication.
The fundamental difference between the lytic and lysogenic cycles of a bacteriophage lies in the fate of the host cell. In the lytic cycle, the virus hijacks the host's machinery to produce new particles, ultimately causing the cell to burst and die. In contrast, the lysogenic cycle allows the viral DNA to integrate into the host chromosome, where it replicates peacefully.

212. (A) Zygomycotina
Rhizopus stolonifer, commonly known as black bread mold, is a well-known member of the fungal division Zygomycotina. This fungus is characterized by the presence of coenocytic hyphae and reproduces sexually through the

formation of thick-walled, resistant zygospores. It is frequently found growing on bread and other food items, where it acts as a saprophyte, breaking down organic matter for energy.

213. (D) Wide metabolic range including autotrophy and heterotrophy.
Eubacteria exhibit an incredibly wide range of nutritional modes, reflecting their diverse ecological roles. While many species are heterotrophic, obtaining energy from organic compounds as saprophytes or parasites, others are autotrophic. Autotrophic bacteria include photoautotrophs that use light energy and chemoautotrophs that derive energy from inorganic chemical reactions. This metabolic flexibility allows Eubacteria to inhabit almost every environmental niche.

214. (B) Bacillariophyta
The algal division Bacillariophyta, which includes the diatoms, is uniquely characterized by having cell walls made of silica. These walls, known as frustules, are highly durable and do not decompose after the organism dies. Over millions of years, the accumulation of these microscopic silica shells in aquatic sediments creates massive deposits of diatomaceous earth, which is commercially harvested for industrial use.

215. (C) Mycotoxin
Aflatoxin is a highly dangerous and carcinogenic mycotoxin produced by several species of molds, particularly those in the genus Aspergillus. These toxins commonly contaminate crops like peanuts, corn, and cottonseed when they are grown or stored under warm, moist conditions. Because they can cause severe liver damage and cancer, monitoring aflatoxin levels in food and animal feed is essential.

216. (D) An E. coli cell
Peptidoglycan is a fundamental component of the cell walls of most bacteria, providing structural integrity and protecting the cell from osmotic pressure. Escherichia coli, a common bacterium, possesses a cell wall that contains a layer of peptidoglycan. In contrast, yeast have cell walls made of chitin, Chlamydomonas uses glycoproteins, and mycoplasmas lack a cell wall entirely, making them unique prokaryotes.

217. (A) An acellular, obligate intracellular parasite.
The most accurate biological description of a virus is that it is an acellular, obligate intracellular parasite. This means that viruses are not made of cells and can only replicate and survive by infecting a living host cell. They lack their own metabolism and ribosomes, relying entirely on the host's machinery to produce new viral components, illustrating their unique biological position.

218. (B) Basidiomycotina
Basidiomycotina, often referred to as 'club fungi', is a major division of the kingdom Fungi. This group is characterized by the production of sexual spores on specialized, club-shaped structures called basidia. It includes a diverse range of organisms, from familiar mushrooms and puffballs to shelf fungi and significant plant pathogens like rusts and smuts. They play crucial roles in ecosystems.

219. (A) 3, 1, 4, 2
Algal groups exhibit increasing pigment complexity based on their evolutionary history and habitat. Cyanobacteria are prokaryotes with simple phycobilins. Chlorophyta possess chlorophylls a and b, similar to land plants. Phaeophyta contain the accessory pigment fucoxanthin for marine life. Rhodophyta, often living at great ocean depths, have complex phycobilins like phycoerythrin that allow them to absorb specific light wavelengths that penetrate.

220. (C) Viroids replicate independently; virusoids need a helper virus.
Viroids and virusoids are both types of small, infectious RNA molecules, but they differ in their replication requirements. Viroids are capable of replicating independently within their host plant cells. In contrast, virusoids require the presence of a specific helper virus for their replication and for the provision of a protein coat. This dependency is the key distinction between these two infectious agents.

221. (B) Formation of petroleum deposits from ancient diatoms.
Bacteria have many essential roles in industry, such as the curing of tea and tobacco, the production of vinegar and alcohol, and the retting of fibers like jute. However, the formation

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of massive petroleum deposits is primarily attributed to the ancient remains of marine plankton, particularly diatoms and algae, rather than being a direct role performed by modern bacterial populations.

222. (A) Both A and R are true and R is the correct explanation of A.
Members of the division Deuteromycotina are traditionally called "imperfect" fungi because their sexual stage of reproduction is either naturally absent or has not yet been discovered by scientists. These organisms reproduce almost exclusively through the production of asexual spores known as conidia. This taxonomic group serves as a temporary classification until the sexual reproductive phase of a fungus is observed.

223. (D) Anchor the alga to a substrate.
The holdfast is a specialized structural component found in many large seaweeds, particularly those in the division Phaeophyta, such as kelps. Its primary biological function is to firmly anchor the alga to a stable substrate, like a rock or the seafloor, in turbulent coastal environments. Unlike the roots of higher plants, a holdfast does not typically absorb nutrients or water.

224. (A) Chlorophyll a and phycobilins.
Cyanobacteria are prokaryotic organisms that possess several distinctive characteristics. They contain chlorophyll a and accessory pigments called phycobilins, which allow them to perform oxygenic photosynthesis. Being prokaryotic, they lack a membrane-bound nucleus and other complex organelles. Their cell walls are typically composed of peptidoglycan, similar to other bacteria, and they play vital roles in aquatic ecosystems as primary producers.

225. (B) Contains genetically distinct nuclei in a common cytoplasm.
Heterokaryosis is a biological condition in fungi where a single mycelium contains genetically distinct nuclei within a common cytoplasm. This state often arises through the fusion of hyphae from different individuals, a process called plasmogamy. Heterokaryosis allows the fungus to maintain genetic diversity and can provide physiological advantages by combining the different genetic traits of the parental nuclei within a unit.

226. (A) P-3, Q-4, R-1, S-2
Different biological agents are characterized by their unique molecular structures. Viruses consist of a nucleic acid genome protected by a protein coat. Viroids are even simpler, consisting solely of infectious RNA. Prions are unique infectious particles composed entirely of misfolded protein. Plasmids are small, extrachromosomal DNA molecules found in bacteria. These distinctions are fundamental for understanding the nature of infectious and genetic agents.

227. (D) Implementation of widespread vaccination programs.
Vaccination is widely recognized as the most effective method for the general population to control and prevent viral diseases. Vaccines work by stimulating the host's immune system to recognize and remember specific viral pathogens without causing the disease itself. This provides long-term protection and has been successful in eradicating or significantly reducing many serious viral infections like smallpox, polio, and measles.

228. (A) Parasitic alga
The 'red rust of tea' is a unique plant disease because it is caused by a parasitic green alga, Cephaleuros virescens, rather than a fungus or bacterium. This alga grows on the leaves and stems of tea plants, appearing as orange-red velvety patches. This infection can reduce the photosynthetic capacity of the plant and impact crop yields in tropical and subtropical regions.

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229. (B) Four
A basidium is the characteristic club-shaped reproductive structure of the fungal division Basidiomycotina. During sexual reproduction, karyogamy and meiosis occur within the basidium, typically leading to the formation of exactly four haploid basidiospores. These spores are borne externally on small stalks called sterigmata and are eventually released into the environment for dispersal. This external spore production distinguishes Basidiomycetes.

230. (B) 1 and 3 only
Bacteria are prokaryotic organisms that possess several key structural features. They typically have 70S ribosomes for protein synthesis. Their genetic material is located in a region called the nucleoid

and is not enclosed by a nuclear membrane. Additionally, the bacterial cell membrane can form internal folds or invaginations known as mesosomes, which are thought to play roles in respiration and division.

231. (D) Glucans and cellulose
Oomycetes, such as the genus Phytophthora, are a group of organisms that were traditionally classified as fungi but are now known to be more closely related to brown algae and diatoms. One major difference from true fungi is the composition of their cell walls, which are primarily made of glucans and cellulose rather than chitin. This chemical distinction is taxonomically.

232. (A) A flattened sheet or complex body of tissue-like cells.
An alga with a parenchymatous thallus organization exhibits a relatively complex body structure. Instead of being a single cell or a simple filament, it consists of multiple layers of cells that form a flattened, leaf-like sheet or a complex three-dimensional tissue. This level of organization provides a large surface area for photosynthesis and is seen in species like sea lettuce.

233. (A) Both Statement I and Statement II are true.
Lichens are vital pioneer colonizers because they can survive on bare rock and other harsh, barren surfaces. The fungal partner plays a crucial role in this process by secreting organic acids that chemically break down the rock surface. This action, combined with the physical expansion of hyphae, initiates the process of soil formation, eventually creating an environment where other plants grow.

234. (C) Their cell walls contain peptidoglycan.
Archaebacteria are distinguished from Eubacteria by several fundamental biochemical differences. While Eubacteria possess cell walls containing peptidoglycan, the cell walls of Archaebacteria completely lack this material. Instead, they are composed of proteins or other polysaccharides like pseudo-peptidoglycan. This distinction, along with their unique membrane lipids, reflects the deep evolutionary divergence between these two groups of prokaryotic organisms in nature.

235. (A) To capture light energy for photosynthesis.
The primary biological role of pigments like chlorophylls and carotenoids in algae is to capture light energy for the process of photosynthesis. Chlorophyll a is the main pigment that initiates these reactions, while accessory pigments like carotenoids and xanthophylls absorb additional light wavelengths and protect the cell from damage. This energy is then used to synthesize organic molecules for survival.

236. (B) Cyanobacteria
Cyanobacteria are a unique group of prokaryotic organisms that perform oxygenic photosynthesis, using the same basic mechanism as plants. They use chlorophyll a to capture light and release oxygen as a byproduct. This process is ecologically significant as it contributed to the creation of Earth's oxygen-rich atmosphere. Despite their plant-like photosynthesis, they lack a membrane-bound nucleus and other complex organelles.

237. (C) It can reproduce sexually from a single thallus (self-fertile).
A fungus is described as homothallic if a single thallus or individual is capable of completing sexual reproduction on its own. These organisms are self-fertile and do not require a compatible partner of a different mating type. This reproductive strategy ensures that sexual reproduction can occur even when the population density is low or when no suitable partners are available in the environment.

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238. (D) An extrachromosomal plasmid
Antibiotic resistance in bacteria is frequently conferred by specific genes located on extrachromosomal plasmids. These small, circular DNA molecules can replicate independently and are often transferred between different bacterial cells through processes like conjugation. When a gene for resistance, such as for kanamycin, is carried on a plasmid, it can rapidly spread through a bacterial population, posing a challenge.

239. (B) Large, complex, and parenchymatous
The Phaeophyta, or brown algae, are characterized by their large and structurally complex thallus organization. Many species exhibit parenchymatous growth, where cells divide in multiple planes to form complex tissue-

like bodies. This is particularly evident in large seaweeds like kelp, which have specialized structures for attachment and photosynthesis. This level of complexity distinguishes them from simpler unicellular or filamentous algal groups.

240. (A) Ringworm
Ringworm is a common skin infection in humans that is caused by several types of fungi, rather than a parasitic worm. These fungi thrive on keratin, the protein found in skin, hair, and nails. Other human diseases like polio and smallpox are caused by viruses, while cholera is a bacterial infection. Understanding the type of pathogen is essential for effective treatment.

241. (A) Both A and R are true and R is the correct explanation of A.
Mycoplasmas are described as pleomorphic because they can exist in a variety of different shapes and sizes. This ability is directly linked to the fact that they completely lack a rigid cell wall, being enclosed only by a flexible plasma membrane. This structural absence allows them to change their form easily, which is an important feature for their identification and survival.

242. (C) Endocytosis
Endocytosis is a common process of viral entry into animal host cells. In this mechanism, the host cell membrane surrounds and engulfs the entire viral particle, bringing it into the cytoplasm inside a vesicle. This is a highly regulated process that often involves specific interactions between viral proteins and host cell surface receptors, allowing the virus to bypass the cell.

243. (D) Heterokont (two unequal flagella, one tinsel and one whiplash)
The flagellation pattern in the algal class Xanthophyta is typically heterokont. This means that motile cells possess two dissimilar flagella of unequal length. Usually, one is a longer tinsel flagellum covered with fine hairs, while the other is a shorter, smooth whiplash flagellum. This characteristic arrangement is a key taxonomic feature used to classify and distinguish these yellow-green algae from others.

244. (A) Mastigomycotina produce motile spores, while Zygomycotina do not.
A major biological difference between the fungal divisions Mastigomycotina and Zygomycotina lies in their methods of asexual reproduction. Mastigomycotina are characterized by the production of motile asexual spores called zoospores, which are equipped with flagella. In contrast, Zygomycotina produce non-motile spores that are typically dispersed by air or water currents. Both groups generally possess coenocytic hyphae, but spore motility differs.

245. (B) All algal blooms are beneficial for aquatic life.
While algae are essential primary producers and oxygen sources in aquatic ecosystems, not all algal blooms are beneficial. Rapid, excessive growth of certain algae can lead to several problems, such as the production of toxins that are harmful to marine life and humans. Furthermore, the eventual death and decomposition of the bloom can deplete dissolved oxygen, leading to mass fish kills.

246. (C) The phage injects its nucleic acid into the host.
A key characteristic of the bacteriophage replication cycle is the specific way the virus enters the host. Unlike many animal viruses that enter the cell whole, a bacteriophage typically attaches to the bacterial surface and injects only its nucleic acid genome into the cytoplasm. The empty protein capsid remains outside the cell, while the viral genetic material takes control of reproduction.

247. (D) Two distinct haploid nuclei coexist and divide.
In the life cycle of many fungi, a dikaryotic phase is a period where each cell contains two separate and genetically distinct haploid nuclei. This state occurs after the fusion of cytoplasm from two compatible mating types (plasmogamy) but before the actual fusion of the nuclei themselves (karyogamy). This unique cellular organization is particularly prominent in the Ascomycotina and Basidiomycotina divisions.

248. (B) 3, 1, 2
Sexual reproduction in fungi typically follows a strictly ordered sequence of three major phases. It begins with plasmogamy, the fusion

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of cytoplasm from two compatible parental cells. This is followed by karyogamy, the fusion of the haploid nuclei to form a diploid zygote. Finally, meiosis occurs to return to the haploid state, producing genetically recombinant spores for the next generation of fungi.

249. (A) They are obligate intracellular prokaryotic parasites.
Rickettsia are a specialized group of bacteria that function as obligate intracellular prokaryotic parasites. This means they can only survive and replicate inside the living cells of their hosts, typically humans or other animals. They possess a cell wall and metabolic machinery but are dependent on the host for certain nutrients and energy. They are often transmitted to humans via vectors.

250. (B) P-2, Q-4, R-1, S-3
Fungal divisions are distinguished by unique structural features and reproductive methods. Clamp connections are characteristic of Basidiomycotina, while zygospores are formed by Zygomycotina. Ascomycotina are defined by the production of ascocarps, and Mastigomycotina are noted for having motile zoospores. These various structures play essential roles in the growth, survival, and reproduction of these different groups of fungi throughout their life cycles.

251. (B) A nucleic acid genome and a capsid.
The ultra-structure of every typical virus is fundamentally composed of two main parts: a nucleic acid genome and a protective protein shell called a capsid. The genome consists of either DNA or RNA and contains the instructions for making new viral particles. The capsid shields this genetic material from environmental damage and facilitates the infection of new host cells by viruses.

252. (A) Their fungus-like growth and antibiotic production.
Actinomycetes are a significant group of Gram-positive bacteria that are characterized by their filamentous, branching growth pattern, which superficially resembles the mycelium of a fungus. They are of great medical and economic importance because they are the primary source of many essential antibiotics used in medicine today. Despite their fungus-like appearance, they are strictly prokaryotic and possess bacterial cell walls.

253. (A) Both Statement I and Statement II are true.
Algal groups are often named and classified based on their characteristic colors, which result from specific pigment combinations. The brownish color of Phaeophyta (brown algae) is primarily due to the presence of the accessory pigment fucoxanthin. Similarly, the red color of Rhodophyta (red algae) is caused by an abundance of the phycobilin pigment phycoerythrin. These pigments are essential for photosynthesis.

254. (D) Mycoplasma
"Witches' brooms" is a distinctive plant disease symptom characterized by an abnormal, dense proliferation of branches, often caused by the distortion of the plant's hormonal balance. This condition is most frequently associated with infections by mycoplasmas or phytoplasmas, which are wall-less prokaryotic organisms. These pathogens inhabit the plant's phloem and are typically transmitted by sap-sucking insects like leafhoppers or planthoppers.

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255. (B) Sordariomycotina
In the systematic classification of fungi, the major subdivisions are typically given names ending in the suffix "-mycotina". Examples include Zygomycotina, Ascomycotina, Basidiomycotina, and Chytridiomycotina. While "Sordariomycotina" might sound similar, the correct name for the relevant subdivision is often Sordariomycetes, which is a class within the Ascomycota. This nomenclature helps researchers organize and identify different groups of fungal.

256. (C) Budding
Budding is the most common form of asexual reproduction in unicellular fungi like yeast. During this process, a small protrusion or 'bud' forms on the surface of the parent cell. The nucleus then divides, and one daughter nucleus moves into the developing bud. Once the bud reaches a certain size, it eventually detaches to become an independent daughter cell of yeast.

257. (D) Many Eubacteria are heterotrophic, while Cyanobacteria are photosynthetic.
A key biological difference between most Eubacteria and Cyanobacteria lies in their mode of nutrition. While many Eubacteria are heterotrophic, obtaining their energy from organic compounds as saprophytes or parasites, Cyanobacteria are strictly photosynthetic autotrophs. They perform oxygenic photosynthesis, using chlorophyll a to harvest light energy and release oxygen, making them fundamental primary producers in many aquatic and terrestrial ecosystems.

258. (B) Archaebacteria
Archaebacteria are a unique group of prokaryotic organisms that are distinguished by several fundamental features. They are known for their ability to thrive in some of Earth's most extreme environments, such as hot springs and salt lakes. Their cell membranes contain unique ether-linked lipids, and unlike Eubacteria, their cell walls completely lack peptidoglycan. These molecular adaptations reflect their ancient history.

259. (B) Mycology
Mycology is the branch of biology dedicated to the systematic study of fungi, including their genetic and biochemical properties, their taxonomy, and their ecological roles. This field covers everything from microscopic yeasts and molds to large mushrooms and complex symbiotic associations like lichens and mycorrhizae. Mycology is essential for understanding plant diseases, food production, and the discovery of new life.

260. (C) Charophyta
The algal group Charophyta is widely recognized by biologists as being the most closely related to the ancestors of all terrestrial plants. This evolutionary link is based on several shared characteristics, including similar methods of cell division, sperm cell structure, and the presence of the same types of chlorophylls (a and b). These shared traits provide strong evidence for evolutionary history.

261. (D) Fungal hyphae penetrating into the root cortical cells.
An endomycorrhiza is a type of symbiotic association between a fungus and the roots of a plant. It is characterized by the fungal hyphae growing into the root tissues and actually penetrating the individual cortical cells. This internal growth often leads to the formation of specialized structures like arbuscules, which provide a large surface area for the exchange of nutrients between partners.

262. (A) Lysis
Lysis is the process that occurs at the end of a lytic viral infection, where the host cell membrane is ruptured, leading to the death of the cell. This destruction is caused by the production of specific viral enzymes that weaken the cell wall or membrane. The resulting rupture allows the newly assembled, infectious viral particles to be released into the environment.

263. (B) Fragmentation
Spirogyra is a filamentous green alga that commonly reproduces asexually through a process called fragmentation. During this process, the long, thread-like thallus breaks into smaller pieces due to mechanical stress or environmental factors. Each individual fragment then continues to grow and divide through mitosis, eventually developing into a new, independent filament. This method allows for rapid population growth in favorable aquatic.

264. (C) Algae lack complex reproductive structures and tissues.
The primary reason why algae are classified separately from plants is their relatively simple level of organization. Unlike higher plants, algae lack a complex system of true roots, stems, and leaves with specialized vascular tissues like xylem and phloem. Additionally, they do not possess the elaborate multicellular reproductive structures, such as flowers or seeds, that are characteristic of the plant kingdom.

265. (A) Both A and R are true and R is the correct explanation of A.
Antibiotics like penicillin are designed to target specific biological structures and metabolic pathways found in bacteria, such as the synthesis of the peptidoglycan cell wall. Because viruses are acellular and lack these bacterial structures and metabolic processes, they are naturally insensitive to these drugs. This fundamental biological difference is why antibiotics are

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ineffective for treating viral infections like the common cold.

266. (A) 3, 4, 1, 2
The sexual life cycle of a fungus follows a precise chronological sequence of events. It begins with plasmogamy, the fusion of cytoplasm from two compatible mating types. This is followed by karyogamy, the fusion of the haploid nuclei to form a diploid zygote. Meiosis then occurs to produce recombinant haploid spores, which eventually undergo germination to form a new mycelium, starting the process.

267. (D) Silica
The cell wall of a diatom, known as a frustule, is a unique biological structure composed of two overlapping halves. This wall is primarily made of silica, specifically opaline or hydrated silicon dioxide. The indestructible nature of silica allows these intricate walls to be preserved after the death of the organism, leading to the formation of vast deposits of diatomaceous earth over time.

268. (A) Holozoic
Bacteria exhibit an incredibly diverse range of nutritional modes, allowing them to occupy almost every ecological niche. They can be saprophytic, decomposing dead organic matter, or parasitic, living on a host. Others are autotrophic, using light energy for photosynthesis or energy from inorganic chemicals for chemosynthesis. However, they do not exhibit a holozoic mode of nutrition, which involves the ingestion of.

269. (C) Mycoplasma
The "little leaf" disease of brinjal (eggplant) is a common and destructive condition caused by a mycoplasma-like organism, now more commonly called a phytoplasma. This pathogen is transmitted by leafhoppers and infects the plant's phloem. The disease is characterized by a significant reduction in leaf size and an abnormal proliferation of branches, which prevents the plant from producing normal fruit or seeds.

270. (B) Carbohydrates from photosynthesis
In the symbiotic partnership of a lichen, the phycobiont (the algal or cyanobacterial partner) performs the essential role of energy production. Through the process of photosynthesis, it captures light energy to synthesize carbohydrates from carbon dioxide and water. These organic nutrients are then shared with the fungal partner, the mycobiont. This provides the primary energy source for the entire symbiotic organism.

271. (D) A single, circular DNA molecule in a nucleoid region.
Prokaryotes, such as bacteria, are characterized by a relatively simple genetic organization. Their primary genetic material typically consists of a single, circular DNA molecule that is located in a region of the cytoplasm called the nucleoid. Unlike eukaryotic cells, this DNA is not enclosed within a membrane-bound nucleus and is generally not associated with the complex histone proteins found in eukaryotes.

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272. (A) Dimorphic
Fungi that have the ability to switch between two different morphological forms depending on their environmental conditions are called dimorphic. Typically, these fungi grow as single-celled yeasts at higher temperatures, such as inside a host body, and as multicellular molds with hyphae at lower temperatures in the environment. This flexibility is often associated with pathogenicity, allowing the fungus to adapt to hosts.

273. (D) Statement I is false, but Statement II is true.
The parasexual cycle is a non-standard genetic process that allows for recombination in certain fungi without a traditional sexual life cycle. While it involves plasmogamy and karyogamy, it does not involve the process of meiosis. Instead, it relies on mitotic crossing-over and a gradual loss of chromosomes through haploidization. This mechanism is a significant source of genetic variation in many fungi.

274. (B) Have thickened walls to maintain an anaerobic environment.
Heterocysts are specialized cells in certain filamentous cyanobacteria that are uniquely adapted for atmospheric nitrogen fixation. Because the enzyme nitrogenase is highly sensitive to oxygen, heterocysts possess significantly thickened cell walls that help maintain an anaerobic internal environment. This allows the bacteria to convert nitrogen gas into ammonia even while living in oxygen-rich aquatic or terrestrial habitats where they generally thrive.

275. (C) Type of chlorophyll and accessory pigments.
A key biological difference between the algal divisions Chlorophyta and Phaeophyta lies in their specific combinations of photosynthetic pigments. Chlorophyta, or green algae, possess chlorophylls a and b, which gives them their characteristic grass-green color. In contrast, Phaeophyta, or brown algae, contain chlorophyll a and c, along with an abundance of the accessory pigment fucoxanthin, which imparts their distinctive brown color.

276. (C) 1, 2 and 3
In plant pathology, several terms describe the nature of host-parasite relationships. An obligate parasite can only survive on a living host. A facultative saprophyte is primarily a parasite but has the flexibility to live on dead organic matter if necessary. A biotroph is a specialized type of parasite that maintains its host's life while deriving nutrients from it for growth.

277. (D) Mycelium
The vegetative body of most fungi is composed of an extensive network of microscopic, thread-like filaments called hyphae. The entire mass of these interconnected hyphae is collectively known as a mycelium. The mycelium is responsible for the fungus's growth, nutrient absorption from its substrate, and overall survival. It can be compact, forming structures like mushrooms, or broadly spread throughout the.

278. (A) Vertical transmission
The transmission of an infectious agent, such as a virus, from a parent to their offspring during pregnancy, birth, or through breastfeeding is known as vertical transmission. This is a common way for certain pathogens like HIV or Hepatitis B to spread. This mode of transfer is distinct from horizontal transmission, which occurs between individuals through direct contact or environmental factors.

279. (B) They are all eukaryotic.
All members of the Kingdom Fungi share the fundamental characteristic of being eukaryotic organisms. This means their cells contain a membrane-bound nucleus and other complex organelles. While they exhibit diverse lifestyles, such as being saprophytic or parasitic, and can be either unicellular or multicellular, this eukaryotic cellular organization is a universal trait that distinguishes them from the prokaryotic organisms of other.

280. (C) Eubacterium
An organism that is unicellular, lacks a nucleus, has a cell wall containing peptidoglycan, and is sensitive to penicillin is classified as a Eubacterium. These traits are characteristic of the domain Bacteria. The presence of peptidoglycan in the cell wall and the sensitivity to specific antibiotics that target its synthesis are key features that distinguish Eubacteria from Archaebacteria and fungi.

281. (A) P-3, Q-2, R-1, S-4
Different biological entities are characterized by their unique molecular components. The capsid is the protein coat of a virus. A prophage represents viral DNA that has been integrated into a bacterial chromosome. Viroids are composed of infectious RNA without a protein shell. Prions are unique infectious agents made entirely of misfolded protein. These distinctions are essential for the proper study of.

282. (C) Two haploid nuclei which have not yet fused.
A unique and characteristic feature of a dikaryotic cell in the fungal life cycle is that it contains two separate and genetically distinct haploid nuclei. This state occurs after the fusion of cytoplasm from two compatible parental cells (plasmogamy) but before the final fusion of the nuclei themselves (karyogamy). This prolonged dikaryotic phase is particularly prominent in the Ascomycotina and Basidiomycotina.

283. (B) Pigmentation, reserve food, and flagellation are key criteria.
Algal classification is based on several key biochemical and structural criteria. The most important factors include the specific types of photosynthetic pigments, the chemical nature of their reserve food materials, and the number and type of flagella present on motile cells. These traits are more fundamental for distinguishing between various algal divisions than thallus structure alone, although thallus organization is.

284. (D) Oxygen
The enzyme nitrogenase, which is responsible for the critical process of atmospheric nitrogen

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fixation, is highly sensitive to the presence of oxygen. Oxygen can permanently inactivate the enzyme by binding to its reactive centers. Consequently, nitrogen-fixing organisms have evolved various strategies to protect nitrogenase, such as forming specialized thick-walled heterocysts or performing fixation during the night in some photosynthetic.

285. (A) Algal bloom
An algal bloom is a natural phenomenon characterized by the rapid and excessive growth of a single-celled photosynthetic organism, often triggered by an influx of nutrients into an aquatic environment. These blooms can significantly impact coastal ecosystems by producing toxins or by depleting dissolved oxygen through decomposition, which often leads to massive fish kills and other adverse ecological events.

286. (A) Both A and R are true and R is the correct explanation of A.
Oogamy is considered the most advanced type of sexual reproduction found in various algal groups. It is characterized by the fusion of two highly specialized and dissimilar gametes: a large, non-motile female gamete, often called an egg, and a much smaller, motile male gamete. This specialization increases the chances of successful fertilization and reflects a higher level of evolutionary development.

287. (B) Autotrophic mode of nutrition
Fungi are a distinct kingdom of eukaryotic organisms characterized by several key features, including cell walls made of chitin and the storage of reserve energy as glycogen. A fundamental trait that separates them from plants is their heterotrophic mode of nutrition. Because they lack chlorophyll, they cannot perform photosynthesis and must obtain their organic nutrients by absorbing them from dead or living.

288. (C) They can be crystallized like chemicals but can replicate in a host.
Viruses are often considered to be on the borderline between living and non-living entities because they exhibit characteristics of both. While they possess genetic material and can replicate within a living host cell, they lack their own metabolism and can be crystallized like pure chemicals when outside a host. This unique dual nature is a defining feature that distinguishes viruses from others.

289. (D) Basidiomycotina
The fungi responsible for causing rust and smut diseases in significant cereal crops belong to the division Basidiomycotina. These pathogens are characterized by complex life cycles and the production of sexual spores on specialized structures called basidia. They can cause substantial agricultural damage by infecting leaves, stems, and reproductive organs of their host plants, highlighting their economic importance in global agriculture.

290. (A) To provide structural support, protection, and absorb water/minerals.
In the symbiotic association of a lichen, the mycobiont (the fungal partner) plays a primary role in providing structural support and protection for the partnership. It creates a stable thallus that anchors the lichen to its substrate and shields the photosynthetic partner from harsh environmental conditions. Additionally, the fungus is responsible for absorbing water and essential minerals from the environment.

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291. (C) The brown pigment fucoxanthin.
A key diagnostic feature used to identify and classify members of the algal division Phaeophyta, or brown algae, is the presence of the brownish pigment fucoxanthin. This accessory pigment masks the green color of chlorophyll a and c, giving these algae their characteristic olive or brown appearance. Fucoxanthin is highly efficient at capturing the light wavelengths found in coastal waters.

292. (A) Log (exponential) phase
In a typical bacterial growth curve, the log phase, also known as the exponential phase, is the period where the cells are rapidly dividing at a constant and maximum rate. During this time, the population size increases exponentially as the bacteria have access to abundant nutrients and favorable conditions. This phase is characterized by intense metabolic activity and is important.

293. (B) Archaebacteria and Eubacteria
The domain of life that includes all prokaryotic organisms is composed of two major groups:

Archaebacteria and Eubacteria. These organisms are characterized by their simple cellular structure, lacking a membrane-bound nucleus and other complex organelles. In contrast, other groups like algae (Rhodophyta, Chlorophyta) and fungi (Ascomycotina, Basidiomycotina) are eukaryotic, as they possess defined nuclei and specialized internal membrane systems.

294. (A) Both Statement I and Statement II are true.
Viroids are the smallest known infectious agents and are characterized by a genome that consists entirely of a naked, circular, single-stranded RNA molecule. Unlike viruses, they completely lack a protective protein coat or capsid. These unique pathogens are significant causes of disease in many important plant species, illustrating the diversity of infectious agents that can impact agriculture and the plant.

295. (C) Ascomycotina
Fungi that produce their sexual spores within a microscopic, sac-like structure called an ascus are classified as Ascomycotina. Typically, each ascus contains exactly eight haploid ascospores, which are formed after a single round of meiosis and one subsequent mitotic division. This internal development of spores is a key characteristic that distinguishes this group from Basidiomycetes, which produce their spores externally.

296. (D) Asexual reproduction
Binary fission is the primary method of asexual reproduction in bacteria. During this process, a single parent cell replicates its genetic material and then divides into two genetically identical daughter cells. This is a rapid and efficient way for bacterial populations to increase in size when environmental conditions are favorable. While it allows for growth, it does not involve genetic.

297. (A) They are obligate intracellular parasites.
A universal characteristic of all viruses is that they are obligate intracellular parasites. This means they can only replicate and survive by infecting a living host cell. Viruses lack their own metabolic machinery and ribosomes, relying entirely on the host's energy and structural components to produce new viral particles. This total dependency is a fundamental biological trait that distinguishes viruses from life.

298. (B) Increase surface area for water and mineral absorption.
Mycorrhizal associations are highly beneficial to plants because the fungal hyphae significantly increase the surface area of the root system for the absorption of water and essential minerals, particularly phosphorus. In return, the plant provides the fungus with energy-rich carbohydrates produced through photosynthesis. This mutualistic exchange is vital for the growth and survival of many plant species in natural.

299. (C) A single, large, multinucleate cell (coenocytic).
An alga with a siphonaceous thallus, such as Vaucheria, is characterized by its unique cellular organization. It consists of a single, large, multinucleate cell that lacks internal cross-walls or septa. This structure is often called coenocytic and allows for the free movement of cytoplasm and organelles throughout the entire thallus. This organizational form distinguishes these algae from multicellular or unicellular.

300. (B) Eubacteria and Archaebacteria.
In the five-kingdom system of biological classification, all prokaryotic organisms are placed within the Kingdom Monera. This group encompasses two main divisions: the Eubacteria, which include common bacteria and cyanobacteria, and the Archaebacteria, which are often found in extreme environments. Members of Monera are characterized by their simple cellular structure, lacking a membrane-bound nucleus and other complex organelles.

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CHAPTER 02

Biology and Diversity of Bryophytes Pteridophytes and Gymnosperms

1. Which of the following is a defining characteristic of the division Bryophyta?
(A) Presence of a well-developed and complex vascular system
(B) A dominant, photosynthetic gametophyte generation
(C) Production of specialized seeds enclosed within a fruit
(D) An independent and free-living sporophyte plant body

2. Identify the incorrect statement regarding the general characteristics of Pteridophytes.
(A) The main plant body is a differentiated gametophyte stage
(B) They are the first terrestrial plants to possess vascular tissues
(C) They reproduce by spores produced in specialized sporangia
(D) They show a distinct and true alternation of generations

3. Consider the following two statements:
Statement I: Gymnosperms are characterized by the presence of naked ovules not enclosed by any ovary wall.
Statement II: The dominant plant body in Gymnosperms is the gametophyte.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

4. In the class Hepaticopsida, the plant body is typically a dorsiventrally flattened, dichotomously branched thallus. This is a characteristic feature of which of the following?
(A) Mosses
(B) Hornworts
(C) Ferns
(D) Liverworts

5. Match List I with List II regarding plant groups and their characteristics.
List I (Plant Group):
P. Hepaticopsida,
Q. Anthocerotopsida,
R. Bryopsida,
S. Pteropsida.
List II (Feature):
1. Protonema stage,
2. Intercalary meristem,
3. Elaters,
4. True leaves (fronds).
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

6. The presence of a central core of xylem completely surrounded by phloem, with no pith, is characteristic of which type of stele found in Pteridophytes?
(A) Siphonostele
(B) Protostele
(C) Dictyostele
(D) Eustele

7. The distribution of Gymnosperms in India is largely concentrated in which geographical region?
(A) The subtropical coastal plains of Southern India
(B) The arid desert regions of Western Rajasthan
(C) The fertile alluvial Gangetic plains
(D) The Himalayas and Western Ghats regions

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8. Which of the following statements about the class Anthocerotopsida (Hornworts) is correct?
(A) The sporophyte exhibits indeterminate growth
(B) The gametophyte is differentiated into stem and leaves
(C) Each cell contains multiple, discoid chloroplasts
(D) Rhizoids are multicellular with oblique septa

9. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): In Bryophytes, the sporophyte is dependent on the gametophyte.
Reason (R): The sporophyte in Bryophytes is non-photosynthetic and derives its nutrition from the gametophytic tissue.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

10. What is the condition known as heterospory in Pteridophytes?
(A) Producing microspores and megaspores
(B) Production of two different types of gametes
(C) Production of spores at two different times of the year
(D) Production of spores from two different parent plants

11. Which of the following is the most appropriate description of plants belonging to the order Cycadales?
(A) Tall, coniferous trees with needle-like leaves
(B) Liana-like climbing plants with vessel-containing wood
(C) Deciduous trees with fan-shaped leaves
(D) Palm-like plants with pinnately compound leaves

12. Consider the following statements regarding the economic importance of Bryophyta:
1. Sphagnum is used as packing material for trans-shipment of living material due to its water-holding capacity.
2. Bryophytes play a significant role in primary succession on bare rocks.
3. Certain mosses are a primary source of commercial timber.
Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

13. All of the following are characteristics of the class Bryopsida (Mosses) EXCEPT:
(A) The gametophyte is differentiated into a prostrate protonema and an erect leafy gametophore.
(B) The sporophyte possesses a foot, seta, and capsule.
(C) The central part of the capsule, the columella, is typically absent.
(D) Spore dispersal is often aided by a complex structure of peristome teeth.

14. The development of an archegonium that becomes embedded in the prothallus tissue in Pteridophytes is a significant evolutionary step. What is the primary functional advantage of this?
(A) It increases the chances of cross-fertilization.
(B) It enhances the photosynthetic ability of the prothallus.
(C) It facilitates faster dispersal of antherozoids.
(D) It provides better protection and nutrition to the developing embryo.

15. The process by which organic remains of plants are preserved in sedimentary rocks, often as impressions or compressions, is known as:
(A) Fossilization
(B) Petrifaction
(C) Calcification
(D) Carbonation

16. Identify the correct pair related to the anatomy of Bryophytes.
(A) Hepaticopsida - Multicellular rhizoids with oblique septa
(B) Anthocerotopsida - Single large chloroplast with a pyrenoid per cell
(C) Anthocerotopsida - Presence of a central conducting strand (hydroids and leptoids)
(D) Bryopsida - Presence of gemma cups for asexual reproduction

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17. Arrange the following types of steles in the correct evolutionary sequence from most primitive to most advanced.
P. Protostele
Q. Eustele
R. Siphonostele
S. Dictyostele
(A) P, R, S, Q
(B) P, S, R, Q
(C) Q, S, R, P
(D) R, P, Q, S

18. Which statement is incorrect regarding the general characteristics of Psilopsida?
(A) They are considered the most primitive of the living vascular plants.
(B) The plant body is differentiated into true roots, stem, and leaves.
(C) The stele is typically a simple protostele.
(D) The sporangia are borne terminally on aerial branches.

19. The Pteridospermales are commonly known as:
(A) Club mosses
(B) Horsetails
(C) Seed ferns
(D) Conifers

20. A student observes a bryophyte with a prominent leafy gametophore that arose from a filamentous protonema. The sporophyte is differentiated into foot, seta, and capsule, and has peristome teeth. To which class does this specimen most likely belong?
(A) Hepaticopsida
(B) Anthocerotopsida
(C) Psilopsida
(D) Bryopsida

21. The term "amphibians of the plant kingdom" is used to describe Bryophytes because:
(A) They live in water but reproduce on land.
(B) They can survive in both desert and aquatic environments.
(C) They live on land but require water for fertilization.
(D) Their life cycle involves both sporophytic and gametophytic phases.

22. In Pteridophytes, the dominant generation in the life cycle is the:
(A) Gametophyte
(B) Sporophyte
(C) Prothallus
(D) Protonema

23. Consider the following two statements:
Statement I: The process of fossilization is extremely common, and most organisms that have ever lived are preserved as fossils.
Statement II: The Geographical Time Scale divides Earth's history into eons, eras, periods, and epochs based on geological and biological events.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

24. A key anatomical feature used to classify Bryophyta into its major classes (Hepaticopsida, Anthocerotopsida, Bryopsida) is the:
(A) Color of the thallus
(B) Number of antheridia
(C) Length of the rhizoids
(D) Structure of the sporophyte

25. The evolution of heterospory is considered a crucial step towards the development of the seed habit because:
(A) It leads to the elimination of the gametophytic generation.
(B) It allows for more efficient wind pollination.
(C) Megaspore retention protects the female gametophyte.
(D) It increases the number of spores produced by a single plant.

26. Which of the following is a general characteristic of the division Lycopsida?
(A) Leaves are large and pinnately compound (megaphylls).
(B) Leaves are small, simple, and scale-like (microphylls).
(C) The stem lacks any vascular tissue.
(D) They reproduce exclusively by seeds.

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27. The order Cycadeoidales (Bennettitales) is an extinct group of gymnosperms primarily known from which geological era?
(A) Paleozoic Era
(B) Cenozoic Era
(C) Precambrian Era
(D) Mesozoic Era

28. Which of the following is NOT a form of asexual reproduction found in Bryophytes?
(A) Development of zygotes through syngamy
(B) Fragmentation of the thallus
(C) Formation of gemmae
(D) Production of bulbils on the stem

29. Identify the correct statement regarding the anatomy of Pteridophytes.
(A) All pteridophytes possess a simple protostele throughout their life.
(B) Xylem consists only of tracheids; vessels are completely absent in all members.
(C) Phloem lacks sieve tubes and companion cells, having sieve cells instead.
(D) A secondary cambium is present, leading to significant secondary growth in all groups.

30. In gymnosperms, pollination is predominantly carried out by which agent?
(A) Wind (anemophily)
(B) Water (hydrophily)
(C) Insects (entomophily)
(D) Birds (ornithophily)

31. Which class of Bryophyta is characterized by a sporophyte that consists only of a capsule and lacks a foot and seta?
(A) Bryopsida
(B) Anthocerotopsida
(C) Both (B) and (C)
(D) Simple Hepaticopsida like Riccia

32. The strobilus or cone found in certain Pteridophytes like Selaginella and Equisetum is a structure composed of:
(A) A cluster of vegetative leaves
(B) Aggregations of sporophylls bearing sporangia
(C) A modified reproductive stem with flowers
(D) Fused bracts protecting the root tip

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33. Which of the following is a key evolutionary tendency observed among Gymnosperms?
(A) Increasing dependence on water for fertilization
(B) Shift from a dominant sporophyte to a dominant gametophyte
(C) Reduction and simplification of the female gametophyte
(D) Development of herbaceous, annual life forms

34. A significant economic use of Pteridophytes includes their role as:
(A) A major source of food grains
(B) Production of industrial-grade timber
(C) Manufacturing of paper and pulp
(D) Ornamental plants and for soil binding

35. Match List I with List II regarding Gymnosperm orders and examples.
List I (Order):
P. Coniferales,
Q. Cycadales,
R. Ginkgoales,
S. Gnetales.
List II (Example):
1. Ginkgo,
2. Gnetum,
3. Pinus,
4. Cycas.
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-2, S-3

36. In the life cycle of a typical moss (Bryopsida), the leafy plant that we commonly see is the:
(A) Diploid sporophyte
(B) Diploid prothallus
(C) Haploid protonema
(D) Haploid gametophyte

37. The 'origin of seed habit' can be traced back to certain heterosporous Pteridophytes. Which of the following is considered a prerequisite for seed habit?
(A) Development of a protostele
(B) Retention of the megaspore inside the megasporangium
(C) Production of only one type of spore
(D) Dependence on water for fertilization

38. The members of the class Sphenopsida are commonly known as:
(A) Horsetails
(B) Club mosses
(C) Whisk ferns
(D) True ferns

39. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): Gnetales are considered advanced among Gymnosperms and share some characteristics with Angiosperms.
Reason (R): Gnetales possess vessels in their xylem and exhibit a type of double fertilization.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

40. An Indian botanist renowned for his extensive work on Indian Gymnosperms, particularly Cycads and Conifers, is:
(A) P. N. Mehra
(B) Birbal Sahni
(C) P. Maheshwari
(D) S. R. Kashyap

41. The function of elaters in the capsule of Marchantia (Hepaticopsida) is to:
(A) Provide nutrition to the developing spores
(B) Aid in the dispersal of spores
(C) Absorb water for the sporophyte
(D) Form the outer wall of the capsule

42. Consider the following statements about Pteridophytes:
1. They are also known as cryptogams because they lack seeds and flowers.
2. The sporophyte is dependent on the gametophyte for nutrition throughout its life.
3. The group includes ferns, horsetails, and club mosses.

Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

43. Which geological period is often called the "Age of Ferns" due to the abundance and dominance of Pteridophytes?
(A) Silurian
(B) Devonian
(C) Permian
(D) Carboniferous

44. Which of the following is not a general characteristic of Gymnosperms?
(A) Xylem lacks vessels (except in Gnetales).
(B) Phloem lacks companion cells.
(C) Ovules are enclosed within an ovary.
(D) The endosperm is a haploid, pre-fertilization tissue.

45. The leaves of ferns, which are typically large and pinnately compound, are known as:
(A) Microphylls
(B) Sporophylls
(C) Scales
(D) Fronds

46. What is the ploidy level of the protonema stage in the life cycle of a moss?
(A) Diploid (2n)
(B) Haploid (n)
(C) Triploid (3n)
(D) Polyploid

47. Identify the correct pair.
(A) Lycopsida - Microphyllous leaves
(B) Sphenopsida - Jointed stem with whorls of leaves
(C) Psilopsida - True roots and leaves present
(D) Pteropsida - Megaphyllous leaves (fronds)

48. The order Corditales represents a group of:
(A) Living cycads found in tropical regions
(B) Modern conifers like pines and firs
(C) Herbaceous desert-dwelling gymnosperms
(D) Extinct Paleozoic trees with strap leaves

49. What is the most significant ecological role of Bryophytes as pioneer species?
(A) Mat formation preventing erosion and aiding soil creation
(B) They contribute to the decomposition of organic matter.
(C) They serve as a primary food source for large herbivores.

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(D) They fix atmospheric nitrogen, enriching the soil.

50. The development of the entire female gametophyte within the megaspore wall is a key feature related to the origin of the seed habit. This condition is known as:
(A) Exosporic development
(B) Endosporic development
(C) Isosporic development
(D) Aposporic development

51. What is the primary function of the annulus in the sporangium of a typical fern (Pteropsida)?
(A) Photosynthesis
(B) Protection of the developing spores from desiccation
(C) Spore dispersal through a dehiscence mechanism
(D) Absorption of nutrients from the frond

52. Welwitschia mirabilis, a unique gymnosperm found in the Namib desert, belongs to which order?
(A) Cycadales
(B) Ginkgoales
(C) Ephedrales
(D) Welwitschiales

53. Consider the following two statements:
Statement I: In Bryophytes, sexual reproduction is of oogamous type.
Statement II: The male gamete (antherozoid) is non-motile and is carried to the female gamete (egg) by wind.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

54. The central conducting strand in the stem of some mosses, composed of hydroids and leptoids, is analogous to the:
(A) Epidermis and cortex of higher plants
(B) Vascular tissue (xylem and phloem) of higher plants
(C) Pith and medullary rays of higher plants
(D) Pericycle and endodermis of higher plants

55. The presence of circinate vernation, where young leaves are coiled like a watch spring, is a characteristic feature of which group?
(A) Lycopsida
(B) Coniferales
(C) Cycadales and Pteropsida (ferns)
(D) Sphenopsida

56. The Paleozoic, Mesozoic, and Cenozoic are divisions of geological time known as:
(A) Eons
(B) Periods
(C) Epochs
(D) Eras

57. Which of the following is an example of a living fossil among Gymnosperms?
(A) Ginkgo biloba
(B) Pinus roxburghii
(C) Cycas revoluta
(D) Gnetum ula

58. In the anatomy of a Pteridophyte stem, a stele that is broken into a number of discrete vascular strands is called a:
(A) Haplostele
(B) Dictyostele
(C) Actinostele
(D) Plectostele

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59. The gametophytic plant body is a thallus and is not differentiated into root, stem, and leaves in:
(A) All Bryophytes
(B) All members of Bryopsida
(C) Most members of Hepaticopsida and Anthocerotopsida
(D) All Pteridophytes

60. The economic importance of Gymnosperms is immense, primarily due to their use as a source of:
(A) Spices and beverages
(B) Edible fruits and vegetables
(C) Medicinal drugs for a wide range of ailments
(D) Softwood for timber, paper, and resins

61. Which of the following structures is absent in the sporophyte of Anthocerotopsida?
(A) Foot

(B) Capsule
(C) Seta
(D) Columella

62. The male gametes in Pteridophytes are typically:
(A) Non-motile and spherical
(B) Multiciliate and motile
(C) Unicellular and non-flagellated
(D) Carried by pollen tubes

63. Which statement correctly describes an evolutionary trend from Pteridophytes to Gymnosperms?
(A) The gametophyte becomes larger and more complex.
(B) Fertilization becomes independent of external water.
(C) The sporophyte becomes dependent on the gametophyte.
(D) Homospory becomes the dominant condition.

64. Peat, a valuable fuel and horticultural product, is formed from the accumulation and compression of:
(A) Riccia
(B) Marchantia
(C) Funaria
(D) Sphagnum

65. Match List I with List II regarding Pteridophyte groups and features.
List I (Group):
P. Psilopsida,
Q. Lycopsida,
R. Sphenopsida,
S. Pteropsida.
List II (Feature):
1. Jointed stem,
2. Dichotomously branched rhizome,
3. Fronds,
4. Microphylls.
(A) P-1, Q-3, R-4, S-2
(B) P-2, Q-4, R-1, S-3
(C) P-2, Q-1, R-3, S-4
(D) P-3, Q-4, R-1, S-2

66. What best describes the alternation of generations in Bryophytes?
(A) Isomorphic alternation of generations
(B) Heteromorphic alternation of generations with a dominant sporophyte
(C) Heteromorphic alternation of generations with a dominant gametophyte
(D) No true alternation of generations

67. The condition where sporophylls are aggregated to form a definite cone or strobilus is found in:
(A) Most ferns like Dryopteris
(B) Selaginella and Equisetum
(C) All members of Psilopsida
(D) All members of Hepaticopsida

68. The endosperm in gymnosperms is formed _____ fertilization and is therefore _____.
(A) before; haploid (n)
(B) after; triploid (3n)
(C) before; diploid (2n)
(D) after; diploid (2n)

69. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): Most Pteridophytes are homosporous.
Reason (R): The evolution of heterospory in some Pteridophytes was a significant step towards the seed habit.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

70. The presence of pseudo-elaters is a characteristic feature of the sporophyte of which class?
(A) Anthocerotopsida
(B) Hepaticopsida
(C) Bryopsida
(D) Pteropsida

71. A siphonostele with non-overlapping leaf gaps, resulting in a solid tube of vascular tissue, is known as a:
(A) Dictyostele
(B) Plectostele
(C) Eustele
(D) Solenostele

72. Consider the following statements about the anatomy of Gymnosperms:

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1. The wood is typically homoxylous, consisting mainly of tracheids.
2. Companion cells are present in the phloem of all gymnosperms.
3. Resin canals are a common feature in the stems and leaves of Coniferales.

Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

73. The largest and most diverse class of Pteridophytes, commonly known as ferns, belongs to:
(A) Psilopsida
(B) Pteropsida
(C) Lycopsida
(D) Sphenopsida

74. Sago, a type of starch, is commercially extracted from the stems of certain species of:
(A) Pinus
(B) Ephedra
(C) Cycas
(D) Ginkgo

75. The gametophyte of a fern, known as the prothallus, is typically:
(A) A large, leafy structure
(B) A filamentous, branched structure
(C) A subterranean, non-photosynthetic structure
(D) A small, heart-shaped, photosynthetic thallus

76. Which of the following is NOT a characteristic of reproduction in Bryophytes?
(A) Formation of a pollen tube to carry male gametes
(B) Oogamous type of sexual reproduction
(C) Presence of a multicellular, jacketed archegonium
(D) Requirement of water for the movement of antherozoids

77. Arrange the following geological units in chronological order from the oldest to the most recent.
P. Mesozoic Era
Q. Cenozoic Era
R. Paleozoic Era
S. Precambrian Time
(A) S, R, P, Q
(B) R, S, P, Q
(C) S, P, R, Q
(D) Q, P, R, S

78. Which of the following Pteridophytes exhibits heterospory?
(A) Lycopodium
(B) Selaginella
(C) Equisetum
(D) Dryopteris

79. The term 'Pteridospermales' indicates that these plants were morphologically similar to _____ but reproduced like _____.
(A) cycads; angiosperms
(B) mosses; ferns
(C) ferns; gymnosperms
(D) conifers; ferns

80. What is the most significant difference between the sporophyte of a Bryophyte and a Pteridophyte?
(A) The bryophyte sporophyte is diploid, while the pteridophyte sporophyte is haploid.
(B) The bryophyte sporophyte is dependent on the gametophyte, while the pteridophyte sporophyte is independent.
(C) The bryophyte sporophyte produces seeds, while the pteridophyte sporophyte produces spores.
(D) The bryophyte sporophyte has vascular tissue, while the pteridophyte sporophyte does not.

81. In Bryophytes, the neck of the archegonium contains neck canal cells that disintegrate at maturity to:
(A) Form a protective layer around the egg
(B) Develop into a new sporophyte directly
(C) Create a mucilaginous substance to attract antherozoids
(D) Provide nutrition to the egg cell

82. The unique gymnosperm Welwitschia is characterized by having:
(A) A large, unbranched trunk and pinnate leaves
(B) Fan-shaped leaves on long shoots

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(C) Needle-like leaves in clusters
(D) A massive stem with two strap leaves

83. The study of fossils to understand the history of life on Earth is called:
(A) Palynology
(B) Dendrochronology
(C) Paleobotany
(D) Ethnobotany

84. Identify the correct pair based on classification.
(A) Riccia - Bryopsida
(B) Anthoceros - Hepaticopsida
(C) Marchantia - Anthocerotopsida
(D) Funaria - Bryopsida

85. A solenostele that has overlapping leaf gaps is referred to as a:
(A) Dictyostele
(B) Protostele
(C) Plectostele
(D) Haplostele

86. Which feature is characteristic of the order Gnetales?
(A) Presence of archegonia in all members
(B) Presence of vessels in the xylem and similarities to angiosperms
(C) Absence of vessels in the xylem
(D) Production of motile male gametes

87. Which of the following is NOT an economic use of Bryophytes?
(A) As a source of fuel (peat)
(B) As indicators of air pollution
(C) As a major source of timber for construction
(D) In horticulture, to improve soil texture

88. The presence of a ligule, a small scale-like outgrowth on the adaxial surface of the leaf, is a characteristic feature of:
(A) Equisetum and Psilotum
(B) Dryopteris and Pteris
(C) Lycopodium and Huperzia
(D) Selaginella and Isoetes

89. A major contribution to the study of fossil plants in India, leading to the establishment of an institute for paleobotany, was made by:
(A) S. R. Kashyap
(B) P. Maheshwari
(C) Birbal Sahni
(D) J. C. Bose

90. The gametophyte of which of the following Pteridophytes is subterranean and associated with a mycorrhizal fungus?
(A) Lycopodium
(B) Dryopteris
(C) Selaginella
(D) Equisetum

91. The term 'stele' in Pteridophytes refers to the central cylinder of the stem and root, which includes:
(A) The epidermis and cortex only
(B) The pith and medullary rays only
(C) The entire cross-section of the stem
(D) The vascular tissues (xylem and phloem) and pericycle

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92. In which class of Bryophyta are the rhizoids multicellular with oblique septa?
(A) Hepaticopsida
(B) Bryopsida
(C) Anthocerotopsida
(D) All of the above

93. The flowers of Cycadeoidales (Bennettitales) were structurally unique because they were:
(A) Very small and aggregated into catkins
(B) Unisexual and borne on separate male and female plants
(C) Bisporangiate, with both pollen and ovule-bearing structures in a flower-like arrangement
(D) Lacking any perianth or protective structures

94. The life history of a Pteridophyte is characterized by an alternation of a diploid sporophytic generation with a:
(A) Diploid gametophytic generation
(B) Haploid sporophytic generation
(C) Triploid endospermic generation
(D) Haploid gametophytic generation

95. Match List I with List II regarding structures and plant groups.
List I (Structure):
P. Gemma cup,
Q. Strobilus,

R. Resin canal,
S. Pseudo-elater.
List II (Plant Group):
1. Anthoceros,
2. Pinus,
3. Marchantia,
4. Equisetum.
(A) P-3, Q-4, R-2, S-1
(B) P-3, Q-2, R-4, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-2, Q-3, R-1, S-4

96. Which of the following is considered a living representative of the class Psilopsida?
(A) Lycopodium
(B) Psilotum
(C) Equisetum
(D) Selaginella

97. The distribution of Bryophytes is widespread, but they are most commonly found in:
(A) Arid deserts and saline soils
(B) Deep marine environments
(C) Moist, shady habitats
(D) High-altitude snowy peaks

98. The evolution of the seed habit provided plants with a significant adaptive advantage. What is the most important advantage?
(A) It increased the plant's height.
(B) It enhanced the rate of photosynthesis.
(C) It eliminated the need for roots.
(D) It allowed for reproduction and dispersal in drier terrestrial environments.

99. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): In Funaria (a moss), the spores do not directly form the leafy gametophyte.
Reason (R): The spore first germinates to form a filamentous, branched, algal-like stage called the protonema.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

100. In the alternation of generations in Pteropsida (ferns), the archegonia and antheridia are borne on the:
(A) Prothallus
(B) Sporophyte
(C) Strobilus
(D) Sorus

101. What is the ploidy of the endosperm in Pinus (a Gymnosperm)?
(A) Diploid (2n)
(B) Triploid (3n)
(C) Tetraploid (4n)
(D) Haploid (n)

102. Consider the following statements regarding the classification of Bryophyta:
1. Hepaticopsida are commonly called liverworts.
2. Anthocerotopsida are commonly called hornworts.
3. Bryopsida are commonly called horsetails.
Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

103. The stems of Equisetum (Sphenopsida) are characterized by the presence of:
(A) Dichotomous branching and protostele
(B) Large fronds with circinate vernation
(C) Distinct nodes and internodes with ridges and grooves
(D) Microphylls with ligules

104. Which of the following is an extinct order of Gymnosperms?
(A) Coniferales
(B) Cycadales
(C) Gnetales
(D) Corditales

105. The sporophyte of a Bryophyte is attached to the gametophyte via a structure called the:
(A) Foot
(B) Rhizoid
(C) Seta
(D) Calyptra

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106. In Pteridophytes, a cluster of sporangia, often found on the lower surface of a fertile frond, is known as a:
(A) Strobilus
(B) Sorus
(C) Indusium
(D) Ramenta

107. Which statement about the anatomy of a Cycas stem is incorrect?
(A) It has a large pith and cortex.
(B) The vascular bundles are arranged in a ring.
(C) The wood is dense and pycnoxylic.
(D) It shows prominent leaf traces and girdle traces.

108. The calyptra in a moss is a protective covering over the capsule. What is its genetic origin?
(A) It is part of the diploid sporophyte.
(B) It is a new growth from the haploid gametophore.
(C) It is a triploid tissue formed after fertilization.
(D) It is a remnant of the haploid archegonial wall.

109. What is the most likely habitat for a member of the Psilopsida like Psilotum?
(A) Tropical and subtropical regions, often as an epiphyte
(B) Cold, arctic tundra
(C) Dry, sandy deserts
(D) Aquatic, freshwater ponds

110. From an evolutionary perspective, which group shows the most primitive features among the living gymnosperms?
(A) Cycadales
(B) Gnetales
(C) Coniferales
(D) Ginkgoales

111. Identify the incorrect statement regarding the life cycle of Pteridophytes.
(A) The sporophyte and gametophyte are independent at maturity.
(B) Water is essential for the transfer of antherozoids to the archegonium.
(C) Spores are produced by meiosis in the sporangia.
(D) The zygote develops into the gametophyte.

112. The presence of a single, large, plate-like chloroplast with a pyrenoid in each cell of the thallus is a distinguishing feature of:
(A) Hepaticopsida
(B) Anthocerotopsida
(C) Bryopsida
(D) Sphenopsida

113. Resins and turpentine are economically important products obtained from which order of Gymnosperms?
(A) Cycadales
(B) Ginkgoales
(C) Coniferales
(D) Gnetales

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114. The term “alternation of generations” refers to the alternation between:
(A) A sexual phase and an asexual phase
(B) An aquatic phase and a terrestrial phase
(C) A juvenile phase and an adult phase
(D) A haploid gamete-producing phase and a diploid spore-producing phase

115. A protostele in which the xylem core is star-shaped is called an:
(A) Actinostele
(B) Plectostele
(C) Haplostele
(D) Siphonostele

116. Which of the following is a characteristic of the order Ginkgoales?
(A) Represented by many living species worldwide
(B) It is represented by a single living species with fan-shaped, dichotomously veined leaves
(C) Plants have needle-like leaves arranged in fascicles
(D) Seeds are borne in a fleshy cone

117. The function of gemmae in Marchantia is:
(A) Asexual (vegetative) reproduction
(B) Sexual reproduction
(C) Water absorption
(D) Spore protection

118. In the anatomy of an Equisetum stem, the presence of carinal canals and vallecular canals is a distinct feature.

The carinal canals are associated with:
(A) The cortical region
(B) The vascular bundles
(C) The central pith cavity
(D) The epidermis

119. Identify the correct statement regarding the economic importance of Pteridophytes.
(A) They are the primary source of world's lumber.
(B) All Pteridophytes have significant medicinal properties.
(C) Many ferns are used as ornamental plants.
(D) They are a staple food for a majority of the human population.

120. Which feature distinguishes Gymnosperms from Pteridophytes?
(A) Presence of vascular tissue
(B) Dominant sporophytic generation
(C) Production of spores
(D) Formation of seeds

121. The horn-like, elongated sporophyte is a characteristic feature of which Bryophytic class?
(A) Anthocerotopsida
(B) Hepaticopsida
(C) Bryopsida
(D) Marchantiopsida

122. The development of a leafy gametophore from a filamentous protonema is characteristic of the life history of:
(A) Liverworts
(B) Mosses
(C) Hornworts
(D) Ferns

123. The wood of Pinus is described as pycnoxylic, which means it is:
(A) Soft, loose, and non-compact with a large amount of parenchyma
(B) Lacking any true vascular tissue
(C) Hard, dense, and compact with a large amount of xylem tracheids
(D) Composed entirely of vessels and companion cells

124. Which of the following is NOT a part of the sporophyte in a typical moss?
(A) Foot
(B) Seta
(C) Capsule
(D) Rhizoid

125. Match List I with List II regarding geological periods and dominant plant groups.
List I (Time):
P. Carboniferous,
Q. Jurassic,
R. Silurian,
S. Quaternary.
List II (Dominant Group):
1. Angiosperms,
2. Gymnosperms,
3. Pteridophytes,
4. Early land plants.
(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-1, R-3, S-2

126. The gametophyte in Pteridophytes is known as the prothallus. Which of the following statements about it is generally incorrect?
(A) It is a small, inconspicuous structure.
(B) It is the dominant, long-lived phase of the life cycle.
(C) It is free-living and photosynthetic.
(D) It bears the sex organs, antheridia and archegonia.

127. The drug ephedrine, a bronchodilator and decongestant, is obtained from a gymnosperm belonging to the order:
(A) Coniferales
(B) Cycadales
(C) Ephedrales
(D) Ginkgoales

128. What is the main difference between the rhizoids of liverworts and mosses?
(A) Liverworts have multicellular rhizoids, while mosses have unicellular ones.
(B) Liverworts lack rhizoids, while mosses have them.
(C) Liverwort rhizoids have oblique septa, while moss rhizoids do not.
(D) Liverwort rhizoids are unicellular/unbranched; moss rhizoids are multicellular/branched.

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129. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): The leaves of Lycopsida are called microphylls.
Reason (R): Microphylls are small leaves with a single, unbranched vascular trace (vein) that does not create a leaf gap in the stele.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

130. A key anatomical feature of the roots of Cycas is the presence of coralloid roots, which contain:
(A) Mycorrhizal fungi
(B) Nitrogen-fixing cyanobacteria (e.g., Anabaena)
(C) Starch-storing parenchyma
(D) Specialized water-absorbing tissues

131. Which group of Pteridophytes is characterized by a dichotomously branched stem, the absence of true roots, and tiny, scale-like appendages?
(A) Lycopsida
(B) Sphenopsida
(C) Psilopsida
(D) Pteropsida

132. Consider the following characteristics:
1. Production of two types of spores (microspores and megaspores).
2. Formation of a seed.
3. Dominant gametophytic generation.
Which of these are features of Gymnosperms?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

133. The sporogenous tissue in a moss capsule gives rise to spores through which type of cell division?
(A) Meiosis
(B) Mitosis
(C) Amitosis
(D) Endoreduplication

134. Which of the following is a key ecological role of Pteridophytes?
(A) Primary producers in ecosystems
(B) Serving as soil binders and mineral indicators
(C) Crucial role in nitrogen fixation in fields
(D) Main source of food for humans

135. The wood of Cycas is described as manoxylic, which means it is:
(A) Hard, compact, and commercially valuable
(B) Lacking both xylem and phloem
(C) Soft, porous, and has a large amount of parenchyma tissue
(D) Characterized by the presence of vessels

136. Which statement is true for the alternation of generations in Psilopsida?
(A) The gametophyte is larger than the sporophyte.
(B) Both generations are morphologically identical.
(C) The life cycle is completed without a gametophytic stage.
(D) The sporophyte is the dominant, independent generation.

137. Arrange the following events in the evolution of the seed habit in the correct chronological sequence.
P. Retention of megaspore within megasporangium
Q. Development of a protective integument around the megasporangium
R. Evolution of heterospory
S. Reduction to a single functional megaspore per megasporangium
(A) R, S, P, Q
(B) R, P, S, Q
(C) P, R, Q, S
(D) S, P, R, Q

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138. In Bryophytes, where does fertilization and the subsequent development of the embryo take place?
(A) In the antheridium
(B) In the venter of the archegonium
(C) On the surface of the protonema
(D) Within the spore capsule

139. In the life cycle of a fern, the sporangia develop in clusters called sori. These sori are often protected by a flap of tissue called the:
(A) Annulus
(B) Stomium
(C) Indusium
(D) Ramentum

140. Which of the following is NOT a general characteristic of the class Bryopsida (mosses)?
(A) Gametophyte with stem and leaf-like structures
(B) Presence of a protonema stage
(C) Sporophyte with foot, seta, and capsule
(D) Unicellular, unbranched rhizoids

141. The Mesozoic era is known as the "Age of Reptiles," but it was also dominated by which plant group?
(A) Gymnosperms
(B) Bryophytes
(C) Pteridophytes
(D) Angiosperms

142. Significant research on Indian Gymnosperms has primarily focused on which area?
(A) Developing new hybrid varieties for agriculture
(B) Morphological and reproductive studies by Indian botanists
(C) Large scale biofuel production initiatives
(D) Discovering new classes of gymnosperms previously unknown to science

143. The presence of 'trabeculae', which are rod-like structures traversing the sporangial cavity, is a feature of the sporangium in:
(A) Equisetum
(B) Lycopodium
(C) Selaginella
(D) Dryopteris

144. Which part of the Bryophyte life cycle is responsible for asexual reproduction through fragmentation or gemmae?
(A) The sporophyte
(B) The spores
(C) The zygote
(D) The gametophyte

145. What is the fundamental difference between a microphyll (as in Lycopsida) and a megaphyll (as in Pteropsida)?
(A) Microphylls have single veins; megaphylls have complex veins and gaps
(B) Microphylls are photosynthetic, while megaphylls are not.
(C) Microphylls are found on the sporophyte, while megaphylls are on the gametophyte.
(D) Microphylls are large, while megaphylls are small.

146. A student finds a plant with jointed stems, scaly leaves in whorls at the nodes, and a terminal cone-like strobilus.
This plant most likely belongs to:
(A) Lycopsida
(B) Sphenopsida
(C) Psilopsida
(D) Pteropsida

147. All of the following are examples of Coniferales EXCEPT:
(A) Pinus (Pine)
(B) Cedrus (Cedar)
(C) Cycas (Sago Palm)
(D) Abies (Fir)

148. The study of plant fossils is specifically known as:
(A) Paleontology
(B) Paleozoology
(C) Palynology
(D) Paleobotany

149. Identify the incorrect pair regarding Bryophyte classification.
(A) Hepaticopsida - Sphagnum
(B) Hepaticopsida - Marchantia
(C) Anthocerotopsida - Anthoceros
(D) Bryopsida - Funaria

150. In the evolution of the stele, what is a siphonostele?
(A) A solid core of vascular tissue with no pith
(B) A vascular cylinder with a central parenchymatous pith
(C) A stele broken into a network of separate vascular strands
(D) A stele with xylem and phloem in scattered bundles

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151. Which of the following is a general characteristic of the plant body in Psilopsida?
(A) Well-developed roots, stem, and large leaves
(B) A single, unbranched stem with a terminal flower
(C) A subterranean rhizome with branched shoots; roots are absent
(D) A thalloid body with unicellular rhizoids

152. Consider the following two statements:
Statement I: In Pteridophytes, the gametophyte is usually a small, independent thallus called a prothallus.
Statement II: In Gymnosperms, the male and female gametophytes are dependent on and retained within the sporophyte.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

153. A key feature of the order Pteridospermales (seed ferns) is that they possessed:
(A) Angiosperm-like flowers and fruits
(B) Bryophyte-like life cycle
(C) Cones similar to modern conifers
(D) Fern foliage that produced seeds instead of spores

154. What is the ploidy level of the zygote formed in a Bryophyte?
(A) Diploid (2n)
(B) Haploid (n)
(C) Triploid (3n)
(D) It varies between species.

155. Match List I with List II regarding botanical terms and plant associations.
List I (Term):
P. Heterospory,
Q. Protonema,
R. Coralloid roots,
S. Frond.
List II (Definition):
1. Juvenile stage in mosses,
2. Fern leaf,
3. Two kinds of spores,
4. N2-fixing roots.
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

156. The economic importance of Sphagnum moss is primarily due to its use as:
(A) A food source
(B) Peat for fuel and in horticulture
(C) A building material
(D) A source of antibiotics

157. Which class of Pteridophyta includes plants commonly known as “club mosses”?
(A) Psilopsida
(B) Sphenopsida
(C) Lycopsida
(D) Pteropsida

158. The presence of winged pollen grains is a characteristic feature of:
(A) Cycas
(B) Ephedra
(C) Gnetum
(D) Pinus

159. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): Gymnosperms are phanerogams without ovaries.
Reason (R): They bear naked ovules that are exposed on the surface of megasporophylls.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

160. The life history of Lycopsida is best described as:
(A) A dominant, independent sporophyte and a reduced, independent gametophyte
(B) A dominant gametophyte with a dependent sporophyte
(C) A dominant sporophyte with the gametophyte retained within it
(D) Isomorphic alternation of generations

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161. In the classification of Bryophyta, which feature is unique to Anthocerotopsida?
(A) Thalloid gametophyte
(B) Presence of elaters
(C) Sporophyte with an intercalary meristem providing continuous growth
(D) Multicellular rhizoids

162. Consider the following events in the life cycle of a fern:
1. Fertilization occurs on the prothallus.
2. The sporophyte develops from the zygote.
3. Spores are released from the sporangia.
What is the correct sequence of these events?
(A) $1 \rightarrow 2 \rightarrow 3$
(B) $2 \rightarrow 1 \rightarrow 3$
(C) $3 \rightarrow 2 \rightarrow 1$
(D) $3 \rightarrow 1 \rightarrow 2$

163. A fossil that shows petrifaction is one where:
(A) The organic material has been replaced by minerals, preserving the detailed cellular structure.
(B) Only a carbon film of the organism is left.
(C) An impression of the organism is left in the sediment.
(D) The organism is preserved intact in amber or ice.

164. In which group of Gymnosperms are the male gametes large, multiflagellated, and motile, a primitive feature shared with Pteridophytes?
(A) Coniferales and Gnetales
(B) Cycadales and Ginkgoales
(C) Ephedrales and Welwitschiales
(D) Only in extinct Pteridospermales

165. The peristome teeth of a moss capsule exhibit hygroscopic movements that aid in:
(A) Photosynthesis
(B) Water absorption
(C) Spore dispersal
(D) Protection of the capsule

166. A "leaf gap" in the vascular cylinder of a stem is typically associated with:
(A) The departure of a vascular trace to a microphyll
(B) The departure of a vascular trace to a megaphyll
(C) The formation of a branch
(D) The development of a root

167. Which of the following is a characteristic of the anatomy of the Sphenopsida stem (e.g., Equisetum)?
(A) A simple protostele
(B) A eustele with vascular bundles surrounding a large pith cavity, and carinal/vallecular canals
(C) A dictyostele with many scattered meristeles
(D) A solid core of vascular tissue with no pith

168. The evolutionary origin of the seed habit is linked to the retention and germination of the _____ inside the _____.
(A) microspore; microsporangium
(B) megaspore; megasporangium
(C) zygote; antheridium
(D) spore; capsule

169. What is the main structural difference between the sporophyte of Riccia and Funaria?
(A) Riccia has a sporophyte with foot, seta and capsule, while Funaria's is only a capsule.
(B) Riccia's sporophyte is complex, while Funaria's is simple.
(C) Funaria has foot/seta/capsule; Riccia has capsule only
(D) There is no difference in their sporophyte structure.

170. Which of these is an economic importance of Gymnosperms?
(A) Primary source of cereals like wheat and rice
(B) Formation of coal beds from ancient species
(C) Production of sugar and jaggery
(D) Production of chilgoza nuts from Pinus gerardiana

171. The gametophyte of Pteropsida (ferns) is:
(A) Dioecious, with separate male and female plants
(B) A large, leafy, and long-lived structure
(C) Usually monoecious, bearing both antheridia and archegonia
(D) Subterranean and non-photosynthetic

172. The presence of naked seeds is a defining characteristic of which plant division?
(A) Bryophyta

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(B) Pteridophyta
(C) Angiospermae
(D) Gymnospermae

173. Which of the following is NOT a class within the division Bryophyta?
(A) Lycopsida
(B) Hepaticopsida
(C) Bryopsida
(D) Anthocerotopsida

174. The stele in the stem of Selaginella (a Lycopsid) is often a:
(A) Eustele
(B) Protostele (haplostele or siphonostele in different species)
(C) Atactostele
(D) Dictyostele

175. The order Welwitschiales is represented by a single species endemic to the deserts of southwestern Africa. This demonstrates:
(A) Wide geographical distribution
(B) High species diversity
(C) A monotypic and geographically restricted lineage
(D) A recent evolutionary origin

176. Which statement accurately describes the reproductive process in Bryophytes?
(A) Fertilization is internal, but development of the embryo is external.
(B) Antherozoids are transported by wind to the archegonium.
(C) The process is entirely asexual.
(D) Water is necessary for the motile antherozoids to swim to the egg.

177. The term 'alternation of generations' in Psilopsida implies an alternation between a diploid sporophyte and a:
(A) Haploid gametophyte
(B) Diploid gametophyte
(C) Diploid prothallus
(D) Haploid sporangium

178. One of the key evolutionary advancements seen in Gymnosperms over Pteridophytes is the:
(A) Development of vascular tissue
(B) Evolution of the pollen tube for fertilization
(C) Dominance of the sporophyte generation
(D) Production of spores for dispersal

179. A student observes a Bryophyte specimen with a dorsiventrally flattened thallus and unicellular rhizoids. It likely belongs to which class?
(A) Bryopsida
(B) Anthoceros
(C) Hepaticopsida
(D) Sphenopsida

180. The evolution of the stele from a simple protostele to a more complex eustele reflects a trend towards:
(A) Size reduction
(B) Adaptation to an aquatic lifestyle
(C) Decreasing complexity of the vascular system
(D) Increasing structural support and more efficient transport

181. The main plant body in Lycopsida is a _____, which is differentiated into true root, stem, and leaves.
(A) sporophyte
(B) gametophyte
(C) protonema
(D) thallus

182. Which of the following is NOT a feature of the extinct order Cycadeoidales?
(A) Presence of flower-like bisporangiate strobili
(B) Close evolutionary relationship to modern Gnetum
(C) Syndetocheilic stomata
(D) Pinnately compound leaves

183. Identify the correct statement about the distribution of Bryophytes.
(A) They are exclusively found in marine environments.
(B) They are most abundant in dry, hot deserts.
(C) They are found worldwide, but prefer damp and shady places.
(D) They are restricted to the polar ice caps.

184. Heterospory and the seed habit are considered to be advantageous primarily because they:
(A) Increase the speed of water transport in the plant.
(B) Grow to a much greater height.

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(C) Simplify the life cycle by eliminating the gametophyte stage.
(D) Allow reproduction/dispersal in drier terrestrial regions

185. Match List I with List II regarding plants and their classifications.
List I (Plant):
P. Equisetum,
Q. Pinus,
R. Anthoceros,
S. Selaginella.
List II (Class/Order):
1. Anthocerotopsida,
2. Lycopsida,
3. Sphenopsida,
4. Coniferales.
(A) P-3, Q-4, R-1, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

186. What is the primary ecological significance of Bryophytes in a forest ecosystem?
(A) Food source for large mammals
(B) They form a carpet on the forest floor, retaining moisture and preventing soil erosion.
(C) Contribute significantly to the canopy height
(D) Main source of commercial wood

187. The life history of Sphenopsida is characterized by a dominant, jointed-stem sporophyte and a:
(A) Large, dependent gametophyte
(B) Parasitic sporophyte
(C) Small, free-living gametophyte (prothallus)
(D) Absence of a gametophytic stage

188. Which of the following groups of Gymnosperms includes members that possess vessels in their secondary wood?
(A) Cycadales
(B) Ginkgoales
(C) Coniferales
(D) Gnetales

189. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): Pteridophytes are known as vascular cryptogams.
Reason (R): Pteridophytes are the first land plants to possess vascular tissues (xylem and phloem) but they do not produce flowers or seeds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

190. An example of a useful economic product derived from Pteridophytes is:
(A) The production of paper from fern fronds.
(B) The use of Azolla as a biofertilizer in rice paddies.
(C) The extraction of sugar from Equisetum stems.
(D) The use of Lycopodium as a primary food crop.

191. The defining feature of the life cycle in Pteropsida (ferns) is:
(A) A dominant, independent gametophyte
(B) The production of seeds in cones
(C) A dominant, independent sporophyte with large, complex leaves (fronds)
(D) The absence of vascular tissue

192. Consider the following statements about gymnosperm reproduction:
1. All gymnosperms require water for the transfer of male gametes to the ovule.
2. The pollen grain represents the male gametophyte.
3. The ovule develops into a seed after fertilization.
Which of the above statements is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

193. The thallus of Marchantia has specialized structures for asexual reproduction called:
(A) Gemma cups
(B) Antheridiophores
(C) Archegoniophores
(D) Rhizoids

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194. The evolution of a dictyostele from a siphonostele is associated with:
(A) A reduction in plant size
(B) The development of large, complex leaves (megaphylls) that create leaf gaps in the vascular cylinder
(C) A transition to an aquatic habitat
(D) The loss of true leaves

195. Which of the following is an example of a fossil gymnosperm?
(A) Gnetum
(B) Ginkgo
(C) Pteridospermales (Seed Ferns)
(D) Pinus roxburghii

196. Which statement incorrectly describes the alternation of generations in a typical moss?
(A) The diploid sporophyte is nutritionally dependent on the haploid gametophyte.
(B) The haploid gametophyte is the dominant, photosynthetic phase.
(C) Meiosis occurs within the capsule of the sporophyte to produce haploid spores.
(D) Haploid spores germinate to form a diploid protonema.

197. Arrange the following plant groups in the order of their first appearance in the fossil record, from oldest to most recent.
P. Gymnosperms
Q. Angiosperms
R. Bryophyte-like plants
S. Pteridophytes
(A) R, S, P, Q
(B) S, R, P, Q
(C) R, P, S, Q
(D) P, S, R, Q

198. The function of the annulus and stomium in a fern sporangium is related to:
(A) Photosynthesis
(B) Spore dispersal
(C) Nutrient absorption
(D) Protection from herbivores

199. "Sulphur showers" in pine forests are caused by the release of large quantities of:
(A) Rainwater mixed with sulphur compounds
(B) Sulphur-metabolizing bacteria
(C) Yellow, winged pollen grains
(D) Resin droplets from the trees

200. The morphology of a Bryophyte is generally simple. Which of the following structures is absent in all Bryophytes?
(A) Stomata (or analogous pores)
(B) Rhizoids
(C) Thallus-like plant body
(D) True roots

201. Which Pteridophyte group is characterized by having silica in the walls of their epidermal cells, giving them a rough texture?
(A) Sphenopsida
(B) Psilopsida
(C) Lycopsida
(D) Pteropsida

202. The presence of two types of spores, microspores and megaspores, in Selaginella is known as:
(A) Apospory
(B) Heterospory
(C) Apogamy
(D) Homospory

203. Identify the incorrect statement regarding the general characteristics of Gymnosperms.
(A) They are seed-producing plants.
(B) The ovules are naked and not enclosed in an ovary.
(C) Double fertilization is a characteristic feature of all gymnosperms.
(D) The plant body is a sporophyte differentiated into root, stem, and leaves.

204. The sporophyte of which bryophyte class consists of a foot, an intercalary meristem, and a long, horn-like capsule?
(A) Hepaticopsida
(B) Bryopsida
(C) Both A and B
(D) Anthocerotopsida

205. The life history of Pteridophytes differs from that of Bryophytes in that Pteridophytes have:
(A) A dominant, independent sporophyte generation
(B) A dominant gametophyte generation
(C) No vascular tissue
(D) A requirement for water for fertilization

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206. A key evolutionary step that contributed to the origin of the seed habit was the:
(A) Development of flowers
(B) Reduction of the number of functional megaspores to one per megasporangium
(C) Transition from a woody to a herbaceous habit
(D) Evolution of motile sperm

207. Which statement accurately describes the general anatomy of a Pteridophyte?
(A) They lack true vascular tissues, xylem and phloem.
(B) Secondary growth is extensive.
(C) The stele is the central vascular cylinder of the root and stem.
(D) The xylem is composed entirely of vessels.

208. The order Coniferales is economically the most important group of gymnosperms because they provide:
(A) Most of the world's fruit supply
(B) Sago starch
(C) Bio-fertilizers
(D) Softwood for timber, paper pulp, and resins

209. The classification of Bryophyta into Hepaticopsida, Anthocerotopsida, and Bryopsida is primarily based on the:
(A) Morphology of the gametophyte and structure of the sporophyte
(B) Habitat in which they grow
(C) Chemical composition of the cell wall
(D) Type of chlorophyll present

210. What is the most appropriate description for the life cycle of Psilopsida?
(A) Dominant gametophyte, dependent sporophyte
(B) Dominant sporophyte, independent gametophyte
(C) Isomorphic alternation of generations
(D) Absence of sporophytic generation

211. Which gymnosperm order is considered a "living fossil" and is represented by a single species, Ginkgo biloba?
(A) Cycadales
(B) Coniferales
(C) Ginkgoales
(D) Gnetales

212. In the life cycle of a moss, meiosis occurs during the formation of:
(A) Gametes from gametangia
(B) The zygote from the fusion of gametes
(C) The protonema from a spore
(D) Spores from spore mother cells in the capsule

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213. The evolution of a vascular system (stele) was a critical adaptation for terrestrial plants because it:
(A) Provided structural support and allowed for efficient transport of water and nutrients
(B) Aided in sexual reproduction
(C) Protected the plant from herbivores
(D) Enhanced the process of photosynthesis in the leaves

214. The group Pteropsida includes which of the following plants?
(A) Mosses and Liverworts
(B) Ferns
(C) Club mosses and Quillworts
(D) Horsetails

215. Match List I with List II regarding plant structures and associated groups.
List I (Term):
P. Peristome teeth,
Q. Circinate vernation,
R. Coralloid roots,
S. Ligule.
List II (Group):
1. Cycas,
2. Selaginella,
3. Funaria,
4. Ferns.
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

216. Which of the following is NOT an ecological role of Bryophytes?
(A) Soil formation on bare surfaces
(B) Prevention of soil erosion
(C) Acting as bioindicators of pollution
(D) Serving as a major source of atmospheric oxygen

217. A gymnosperm with palm-like habit, large pinnately compound leaves, and motile male gametes belongs to the order:
(A) Cycadales
(B) Coniferales
(C) Ginkgoales
(D) Ephedrales

218. The life history of a homosporous pteridophyte involves the production of:
(A) Two types of spores that develop into unisexual gametophytes
(B) One type of spore that develops into a bisexual gametophyte
(C) Seeds that develop into a new sporophyte
(D) Spores that develop directly into a new sporophyte

219. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): Bryophytes are poorly adapted to a fully terrestrial life.
Reason (R): They lack a vascular system and require an external film of water for their flagellated male gametes to swim to the egg.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

220. The Geological Time Scale is a system used by geologists and paleontologists to:
(A) Predict future geological events
(B) Map the mineral resources of the Earth
(C) Measure the daily rotation of the Earth
(D) Relate geological strata to time and describe the timing of events in Earth's history

221. The general characteristics of Lycopsida include all of the following EXCEPT:
(A) The plant body is a sporophyte differentiated into root, stem, and leaves.
(B) The leaves are large, pinnately compound megaphylls.
(C) The leaves are microphylls, small with a single vein.
(D) Sporophylls are often aggregated into strobili.

222. Consider the following statements:
1. Pteridophytes were the first terrestrial plants to evolve vascular tissue.
2. The dominant phase in the Pteridophyte life cycle is the gametophyte.
3. All Pteridophytes are heterosporous.
Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 3 only
(D) 1, 2 and 3

223. What is the ploidy level of the cells of the prothallus in a fern?
(A) Diploid (2n)
(B) Triploid (3n)
(C) Haploid (n)
(D) Polyploid

224. Which of the following is an example of an extinct group of gymnosperms that had fern-like leaves and bore seeds?
(A) Corditales
(B) Cycadeoidales
(C) Ginkgoales
(D) Pteridospermales

225. A key difference in the anatomy of the sporophyte of Hepaticopsida and Bryopsida is the:
(A) Presence of stomata on the capsule in Bryopsida, but not always in Hepaticopsida.
(B) Absence of a foot in Bryopsida.
(C) Absence of a capsule in Hepaticopsida.
(D) Lack of a seta in Bryopsida.

226. The evolution of the pollen grain in gymnosperms was a significant adaptation because it:
(A) Increased the rate of photosynthesis.
(B) Eliminated the need for external water for fertilization.
(C) Allowed for the development of true roots.
(D) Provided food storage for the embryo.

227. The stems of Sphenopsida are characterized by:
(A) Dichotomous branching and no leaves.
(B) Large, compound leaves.
(C) Being jointed with distinct nodes and internodes.
(D) Being covered in needle-like microphylls.

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228. Which of the following is a primary area of research in the study of Gymnosperms within the Indian context?
(A) The discovery of Gnetum
(B) Studies on genetically modified pines
(C) Initial taxonomical classification
(D) Morphological and embryological studies of Indian species

229. The process of fossilization where the original organic matter is replaced molecule by molecule with minerals is called:
(A) Compression
(B) Impression
(C) Petrifaction
(D) Amber entombment

230. The life history of Pteropsida (ferns) shows an alternation between a large, diploid sporophyte and a:
(A) Large, diploid gametophyte
(B) Small, diploid prothallus
(C) Parasitic haploid gametophyte
(D) Small, haploid prothallus stage

231. The sporophyte in Bryophyta is best described as:
(A) Independent and photosynthetic
(B) Dominant phase of the life cycle
(C) Dependent or semi-dependent on the gametophyte
(D) Absent in most species

232. The main plant body is a sporophyte in all of the following groups EXCEPT:
(A) Pteridophyta
(B) Gymnosperms
(C) Angiosperms
(D) Bryophyta

233. The development of a siphonostele from a protostele involved the formation of a:
(A) Central pith
(B) Cuticle
(C) Secondary cortex
(D) Periderm

234. The presence of vessels in the xylem is a characteristic feature of which gymnosperm group, suggesting a link to angiosperms?
(A) Cycadales
(B) Gnetales
(C) Ginkgoales
(D) Coniferales

235. Which of the following is NOT a general characteristic of the class Hepaticopsida?
(A) The plant body is often a dorsiventral thallus.
(B) Rhizoids are unicellular and unbranched.
(C) The sporophyte contains an intercalary meristem.
(D) Elaters are often present in the capsule to aid spore dispersal.

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236. What is the significance of heterospory?
(A) It facilitates asexual reproduction.
(B) It leads to the production of identical spores.
(C) It represents a primitive plant trait.
(D) It is a prerequisite for the evolution of the seed habit.

237. The general characteristics of Psilopsida include a sporophyte with a dichotomously branched stem and the absence of:
(A) True roots and leaves
(B) A vascular system
(C) Spores
(D) A cuticle

238. Consider the following two statements:
Statement I: The economic importance of gymnosperms lies in their use as sources of timber, paper, and resins.
Statement II: The seeds of Cycas are edible after processing, and 'sago' starch is obtained from its stem.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

239. The structure and development of the sporophyte is a key feature used in the classification of which major plant group?
(A) Algae
(B) Fungi
(C) Bryophyta

(D) Bacteria

240. The alternation of generations in a typical member of the Lycopsida (e.g., Lycopodium) involves:
(A) A dominant and long-lived gametophyte stage
(B) The complete absence of a gametophyte phase
(C) Morphologically identical alternating generations
(D) A dominant sporophyte and small independent gametophyte

241. Which feature of the extinct Cycadeoidales (Bennettitales) is considered advanced and "flower-like"?
(A) Their bisporangiate strobili
(B) Their woody stems
(C) Their pinnate leaves
(D) Their deep root systems

242. Which of the following is a Bryophyte?
(A) Selaginella
(B) Riccia
(C) Equisetum
(D) Pinus

243. The evolution of the stele in Pteridophytes shows a general trend of:
(A) Simplification of the overall plant life cycle
(B) Total loss of the internal vascular structures
(C) Increasing complexity to support larger plant bodies
(D) Transition from a pith-based to a solid core

244. The characteristic features of the order Corditales include tall trees with:
(A) Small, scale-like leaves.
(B) Fronds.
(C) Fan-shaped leaves.
(D) Large, strap-shaped leaves and platyspermic seeds.

245. Match List I with List II regarding plant groups and common names.
List I (Group):
P. Hepaticopsida,
Q. Bryopsida,
R. Sphenopsida,
S. Lycopsida.
List II (Name):
1. Horsetails,
2. Club Mosses,
3. Liverworts,
4. Mosses.
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

246. What is the ploidy of the spore mother cell in a Bryophyte?
(A) n
(B) 2n
(C) 3n
(D) 4n

247. The life history of a fern (Pteropsida) is distinct from a moss because:
(A) The fern has a dominant gametophyte phase.
(B) Ferns reproduce exclusively by producing seeds.
(C) The fern sporophyte is independent and well-differentiated.
(D) Ferns entirely lack any form of vascular tissues.

248. The most significant evolutionary tendency among Gymnosperms is the:
(A) Increasing dependence on water for fertilization
(B) Transition to a thalloid plant body structure
(C) Universal adoption of the homosporous condition
(D) Progressive reduction and dependence of the gametophyte

249. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): The distribution of Gymnosperms in India is prominent in the Himalayan region.
Reason (R): The temperate and cold climatic conditions of the Himalayas are suitable for the growth of conifers like Pinus, Cedrus, and Abies.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.

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(C) A is true but R is false.
(D) A is false but R is true.

250. The anatomy of a Psilopsida stem is characterized by:
(A) A complex dictyostele.
(B) A simple protostele.
(C) A eustele with scattered bundles.
(D) The complete absence of vascular tissue.

251. Which of the following is a general characteristic of the anatomy of Gymnosperms?
(A) Presence of vessels in the xylem of all species.
(B) Presence of companion cells in the phloem.
(C) Wood is generally non-porous and composed of tracheids.
(D) Absence of secondary growth.

252. Consider the following statements about the economic importance of Bryophytes:
1. They are a major source of commercial timber.
2. They are used as packing material for their water retention capacity.
3. They are pioneers in ecological succession on bare rocks.

Which of the above statements is/are correct?
(A) 1 only
(B) 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

253. The sporophyte of a fern produces spores by meiosis within structures called:
(A) Antheridia
(B) Archegonia
(C) Sporangia
(D) Gemmae

254. The alternation of generations in Sphenopsida consists of a dominant sporophyte and a:
(A) Dependent sporophyte.
(B) Dominant gametophyte.
(C) Parasitic gametophyte.
(D) Small, independent gametophyte.

255. The presence of resin canals in the stem and needles is a characteristic feature of which Gymnosperm order?
(A) Coniferales
(B) Cycadales
(C) Ginkgoales
(D) Gnetales

256. Which of the following is NOT a class of Bryophyta?
(A) Bryopsida
(B) Pteropsida
(C) Hepaticopsida
(D) Anthocerotopsida

257. Arrange the following Pteridophyte classes based on a general evolutionary trend from more primitive to more advanced features.
P. Pteropsida
Q. Lycopsida
R. Psilopsida
S. Sphenopsida
(A) R, Q, S, P
(B) P, S, Q, R
(C) R, S, Q, P
(D) Q, S, R, P

258. The origin of the seed habit required the evolution of heterospory and:
(A) The development of flowers.
(B) The retention of the megaspore within the megasporangium (ovule).
(C) The elimination of the sporophyte generation.
(D) A return to an aquatic lifestyle.

259. The general anatomical plan of a Lycopsida stem includes:
(A) Eustele.
(B) Dictyostele.
(C) A protostele or a siphonostele.
(D) No vascular tissue at all.

260. The work of scientists such as P.N. Mehra and Birbal Sahni has been significant in which of the following fields?
(A) Modern plant genetic engineering studies
(B) Biological conservation of Ginkgo species
(C) Identifying evolutionary links in algae
(D) Plant morphology, anatomy, and paleobotany research

261. The study of the life history of Pteropsida reveals a free-living, photosynthetic gametophyte known as a:

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(A) Prothallus
(B) Protonema
(C) Thallus
(D) Strobilus

262. Which feature is common to both Bryophytes and Pteridophytes?
(A) Dominant sporophyte
(B) Presence of motile antherozoids requiring water for fertilization
(C) True roots
(D) Seeds

263. The classification of Pteridophytes into Psilopsida, Lycopsida, Sphenopsida, and Pteropsida is based on:
(A) Preferred geographical habitat
(B) Cellular chemical composition
(C) Nature of the stele, leaf type, and sporangia
(D) Specific number of chromosomes

264. Consider the following two statements:
Statement I: In Gymnosperms, the female gametophyte is a multicellular structure that develops within the megaspore.
Statement II: The endosperm in Gymnosperms is a post-fertilization tissue and is triploid (3n).
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

265. The economic importance of Pteridophytes includes their use as ornamentals (ferns) and:
(A) The role of Azolla in nitrogen fixation.
(B) Wood pulp.
(C) Edible fruits.
(D) Natural rubber.

266. Which of the following describes the advanced features of Gnetales?
(A) The presence of motile sperm and large fronds.
(B) Xylem vessels and a form of double fertilization
(C) A dominant gametophyte generation.
(D) The lack of seeds and flowers.

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267. What is the ploidy of the main plant body in Bryophyta?
(A) Diploid (2n)
(B) Triploid (3n)
(C) Haploid (n)
(D) Variable

268. The evolution of a dictyostele, a stele dissected into a network of vascular strands, is directly linked to the development of:
(A) Microphylls
(B) Roots
(C) Rhizome
(D) Large megaphylls with leaf gaps

269. Which of the following is NOT a characteristic of the order Cycadales?
(A) Fast-growing, deciduous trees with needle-like leaves.
(B) Dioecious plants with large, compact male and female cones.
(C) Presence of circinate vernation in young leaves.
(D) Presence of motile, multiflagellated male gametes.

270. The classification of Bryophytes into three classes is supported by differences in:
(A) The color of the gametophyte.
(B) The structure of the sporophyte and nature of the rhizoids.
(C) Their geographical location only.
(D) The number of spores produced.

271. In the life history of Psilopsida, the sporophyte is dominant and the gametophyte is typically:
(A) A large green photosynthetic plant
(B) A parasitic and dependent structure
(C) A subterranean and saprophytic structure
(D) Entirely absent from the life cycle

272. A key evolutionary tendency seen in the progression from Pteridophytes to Gymnosperms is:
(A) Total elimination of the vascular tissues
(B) Loss of the vascular cambium in stems
(C) Shift to a dominant gametophyte phase
(D) Increasing independence from water for fertilization

273. What are the morphological features of a Marchantia thallus (Hepaticopsida)?
(A) A dichotomously branched, dorsiventral thallus with scales and rhizoids on the ventral surface.
(B) A central stem with spirally arranged leaves.
(C) A filamentous protonema stage.
(D) A single, horn-like sporophyte.

274. Which of the following Pteridophytes is heterosporous and shows an early stage of seed habit development?
(A) Dryopteris
(B) Selaginella
(C) Equisetum
(D) Lycopodium

275. Match List I with List II regarding plant groups and key features.
List I (Group):
P. Bryophyta,
Q. Pteridophyta,
R. Coniferales,
S. Cycadales.
List II (Feature):
1. Naked seeds in cones,
2. Vascular cryptogams,
3. Dominant gametophyte,
4. Palm-like habit.
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

276. What are the characteristic features of the class Bryopsida (mosses)?
(A) Simple thalloid plant body structures
(B) Presence of an intercalary meristem
(C) Absence of specialized vascular tissues
(D) Leafy gametophores with multicellular rhizoids

277. What does the life history of a typical member of the Sphenopsida like Equisetum involve?
(A) A dominant sporophyte and a reduced independent gametophyte
(B) A dominant and entirely independent gametophyte phase
(C) The specialized production of flowers and fruits
(D) A complete dependence on water for all life stages

278. The economic importance of Gymnosperms like Pinus, Cedrus, and Picea is primarily based on their use as:
(A) Food
(B) Timber and pulpwood
(C) Medicinal
(D) Spices

279. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R).
Assertion (A): The fossil record is incomplete.
Reason (R): Fossilization is a rare event that requires a specific set of conditions, and many organisms decompose or are eaten before they can be fossilized.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

280. The anatomy of a Pteropsida (fern) rhizome typically shows a complex stele, such as a:
(A) Simple protostele
(B) Haplostele
(C) Dictyostele or siphonostele
(D) Atactostele

281. Which unique feature is found in the sporophyte of Anthocerotopsida?
(A) It is differentiated into foot, seta, and capsule.
(B) Lacks foot and seta.
(C) Independent.
(D) It possesses an intercalary meristem for prolonged growth.

282. Consider the following statements about the general characteristics of Pteridophytes:
1. The main plant body is a sporophyte.
2. They possess vascular tissue.
3. They produce seeds for reproduction.
Which of the above statements is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

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283. The distribution of Bryophytes is most common in which type of environment?
(A) Deserts
(B) Saline
(C) Cool, moist, and shady areas
(D) Grasslands

284. A key difference between the life history of Gymnosperms and Pteridophytes is that in Gymnosperms:
(A) Free-living
(B) Sporo dep
(C) Water required
(D) The gametophytes are highly reduced and dependent on the sporophyte.

285. Which of the following describes the members of the order Ephedrales?
(A) Dry or arid regions
(B) Aquatic environments
(C) Cold, wet tundra
(D) Tropical rainforests

286. The reproduction in Bryophytes involves antheridia and archegonia which are:
(A) Unicellular and non-jacketed
(B) Multicellular and have a sterile jacket layer
(C) Part of the diploid sporophyte
(D) Found only in the class Bryopsida

287. Which step is considered the final and most crucial development in the origin of the seed habit?
(A) Heterospory
(B) Vascularization
(C) Megaspore retention within the megasporangium (ovule)
(D) Leafy plant body

288. Which of these correctly identifies a general characteristic of the class Pteropsida?
(A) Microphylls
(B) Leaves are large megaphylls, often called fronds
(C) Jointed
(D) Absent

289. Which of the following is NOT an economic use of Gymnosperms?
(A) As a primary source of staple grains like rice and wheat
(B) Timber from conifers
(C) Edible seeds (chilgoza, pine nuts)
(D) Production of resins and turpentine

290. The classification of gymnosperms includes both living and extinct groups. Which of the following is an extinct group?
(A) Coniferales
(B) Pteridospermales
(C) Cycadales
(D) Gnetales

291. The alternation of generations in Bryophytes is described as heteromorphic because:
(A) Identical
(B) Two spores
(C) The gametophyte and sporophyte are morphologically distinct
(D) Two gametes

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292. The stele of a Pteridophyte is composed of:
(A) Epidermis
(B) Pith
(C) Tracheids
(D) Xylem, phloem, and pericycle

293. Which of the following is a key evolutionary advancement of Gymnosperms over earlier plant groups?
(A) Chlorophyll
(B) Cuticle
(C) The evolution of the seed for reproduction and dispersal
(D) A cell wall

294. A general characteristic of the anatomy of the root and stem of Psilopsida is the presence of a:
(A) Eustele
(B) Atactostele
(C) Dictyostele
(D) Protostele

295. Which of the following is a characteristic feature of the Gymnosperm order Gnetales?
(A) Needle-like leaves
(B) Motile sperm
(C) Dominant gametophyte
(D) Absence of archegonia in some members

296. Which of the following components dominates the life cycle of Bryophytes?

(A) Sporophyte
(B) Zygote
(C) Spore
(D) Gametophyte

297. The concept of the 'origin of the seed habit' is best studied by examining certain fossil and living:
(A) Heterosporous Pteridophytes
(B) Bryophytes
(C) Homosporous Pteridophytes
(D) Algae

298. What type of leaves are typically found in the sporophyte of the class Lycopsida?
(A) Large and compound (megaphylls)
(B) Small and simple (microphylls)
(C) Absent
(D) Scale-like and non-photosynthetic

299. The economic importance of gymnosperms extends to food, with edible seeds obtained from:
(A) Ephedra
(B) Taxus
(C) Pinus gerardiana (Chilgoza pine)
(D) Abies

300. Which of the following best summarizes the alternation of generations in the Pteropsida (ferns)?
(A) Dominant gametophyte phase
(B) Equal alternating generations
(C) Absence of sporophyte phase
(D) Dominant sporophyte and small independent gametophyte

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1. (B) A dominant, photosynthetic gametophyte generation
Bryophytes are characterized by a unique life cycle where the haploid gametophyte is the prominent, independent, and photosynthetic phase. Unlike higher plants, the diploid sporophyte is physically attached to and nutritionally dependent on the gametophyte throughout its existence. This group lacks a complex vascular system, relying instead on simple tissues for the conduction of water and nutrients.

2. (A) The main plant body is a differentiated gametophyte stage
In the life cycle of pteridophytes, the dominant phase is the diploid sporophyte, which is differentiated into true roots, stems, and leaves. This represents an evolutionary shift from bryophytes, where the gametophyte is the main plant body. Pteridophytes are also significant for being the first terrestrial plants to develop specialized vascular tissues like xylem and phloem.

3. (C) Statement I is correct but Statement II is incorrect.
Gymnosperms are seed-producing plants where the ovules remain exposed on megasporophylls because they lack an enclosing ovary wall. The dominant generation in their life cycle is the diploid sporophyte, which is independent and highly complex. Conversely, the gametophytic stage is extremely reduced and depends entirely on the sporophyte for its nutrition and survival in terrestrial environments.

4. (D) Liverworts
Liverworts, belonging to the class Hepaticopsida, possess a gametophytic plant body that is typically a dorsiventrally flattened thallus. This thallus often exhibits dichotomous branching and is attached to the substrate via unicellular rhizoids. Unlike mosses, which have an erect and leafy appearance, most liverworts maintain a prostrate growth form closely appressed to moist and shady environmental surfaces.

5. (A) P-3, Q-2, R-1, S-4
Classification of bryophytes and pteridophytes relies on distinct morphological features. Liverworts utilize elaters for spore dispersal, while hornworts possess an intercalary meristem allowing continuous sporophyte growth. Mosses are characterized by a filamentous protonema stage during germination. Ferns, belonging to the class Pteropsida, are distinguished by their large, complex, and highly developed leaves known as megaphylls or fronds.

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6. (B) Protostele
The protostele represents the most primitive type of vascular arrangement found in early terrestrial plants. It consists of a solid central core of xylem tissue that is entirely surrounded by a layer of phloem. Because there is no central region of parenchyma, this configuration lacks a pith, which distinguishes it from more advanced stelar structures like the siphonostele.

7. (D) The Himalayas and Western Ghats regions
In India, the distribution of gymnosperms is primarily restricted to high-altitude areas with temperate climates. The Himalayan mountain range provides the necessary cool temperatures and environmental conditions for diverse species like pines, cedars, and firs. Additionally, some members are found in the Western Ghats, where high rainfall and specific microclimates support their unique growth and successful reproduction.

8. (A) The sporophyte exhibits indeterminate growth
Hornworts are distinguished by a sporophyte that contains an intercalary meristem located at its base. This specialized tissue allows the capsule to grow continuously over an extended period, resulting in a characteristic horn-like shape. Unlike other bryophytes, their sporophyte possesses photosynthetic tissue and stomata, though it remains attached to the thalloid gametophyte for its supply of water.

9. (A) Both A and R are true and R is the correct explanation of A.
Bryophytes exhibit a life cycle where the diploid sporophyte is physically attached to the haploid gametophyte. Because the sporophyte often lacks sufficient photosynthetic capacity and true roots, it depends on the gametophytic tissue for its primary supply of water, minerals, and organic nutrients. This parasitic relationship is a fundamental characteristic that defines the reproductive biology of this group.

10. (A) Producing microspores and megaspores
Heterospory is an evolutionary condition where a single plant produces two distinct types of spores differing in size and function. Microspores are smaller and eventually develop into male gametophytes, while megaspores are larger and give rise to female gametophytes. This development is considered a crucial milestone because it established the biological foundation necessary for the subsequent evolution of seeds.

11. (D) Palm-like plants with pinnately compound leaves
Members of the order Cycadales are characterized by a stout, unbranched trunk and a crown of large, pinnately compound leaves, giving them a palm-like appearance. These plants are dioecious, meaning male and female reproductive structures are borne on separate individuals. They represent an ancient lineage of gymnosperms that retain several primitive features, including motile, multiflagellated male gametes.

12. (B) 1 and 2 only
Sphagnum moss is highly valued in horticulture for its exceptional water-holding capacity, making it ideal for transporting living plants. Ecologically, bryophytes are vital as pioneer species that colonize bare rocks, initiating soil formation through chemical weathering and organic accumulation. However, mosses are not sources of commercial timber, as they lack the secondary wood and size required.

13. (C) The central part of the capsule, the columella, is typically absent.
In the class Bryopsida, the sporophyte capsule is a complex structure that typically contains a central sterile tissue known as the columella. This structure provides mechanical support and may aid in nutrient transport to the developing spores. Additionally, mosses are known for their sophisticated spore dispersal mechanisms involving peristome teeth, which respond to changes in environmental humidity levels.

14. (D) It provides better protection and nutrition to the developing embryo.
The transition to an embedded archegonium within the prothallus tissue is a significant evolutionary development in pteridophytes. This internal placement shelters the developing zygote and embryo from environmental stresses, such as desiccation. By being surrounded by gametophytic tissue, the young sporophyte can more efficiently absorb nutrients required for its early growth until it becomes independent and fully photosynthetic.

15. (A) Fossilization
Fossilization is the complex biological and geological process by which plant remains are preserved in the Earth's crust over millions of years. This often results in various forms, such as compressions where organic matter remains, or impressions that capture only the external shape. These records are essential for reconstructing past environments and understanding the evolutionary history of different plant groups.

16. (B) Anthocerotopsida - Single large chloroplast with a pyrenoid per cell
A defining anatomical feature of the class Anthocerotopsida is the presence of a single, large, plate-like chloroplast in each cell of the thallus. This chloroplast uniquely contains a pyrenoid, a structure involved in carbon fixation, which is rare among land plants but common in algae. This characteristic highlights the distinct evolutionary position of hornworts within the broader bryophyte division.

17. (A) P, R, S, Q
The evolution of the stele shows a trend toward increasing complexity and efficiency. The protostele is the most primitive form, followed by the siphonostele, which possesses a central pith. The dictyostele represents further advancement with vascular tissue divided by leaf gaps. Finally, the eustele, characterized by discrete vascular bundles arranged in a ring, is seen in the most advanced lineages.

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18. (B) The plant body is differentiated into true roots, stem, and leaves.
Psilopsida includes the most primitive vascular plants, characterized by a relatively simple body plan. Their sporophyte consists of a dichotomously branched aerial stem and a subterranean rhizome, but it completely lacks true roots and leaves. Instead, small scale-like appendages may be present. This lack of complex organs distinguishes them from more advanced vascular groups like ferns and seed plants.

19. (C) Seed ferns
Pteridospermales are an extinct group of gymnosperms frequently referred to as seed ferns. Despite their fern-like foliage, they were distinguished by the production of true seeds rather than spores. This group serves as a critical evolutionary link, illustrating how the seed habit developed within lineages that still retained many morphological characteristics of more primitive, non-seed-bearing vascular plants.

20. (D) Bryopsida
The presence of a leafy gametophore arising from a filamentous protonema stage is a diagnostic feature of the class Bryopsida, commonly known as mosses. Their sporophytes are typically composed of a foot, seta, and capsule, with the latter often featuring a specialized peristome for controlled spore dispersal. These characteristics distinguish mosses from liverworts and hornworts, which have different structures.

21. (C) They live on land but require water for fertilization.
Bryophytes are often termed the amphibians of the plant kingdom because of their specific reproductive requirements. While the adult plant body is adapted to terrestrial habitats, they still rely on an external film of water to facilitate sexual reproduction. The male gametes, or antherozoids, are flagellated and must swim through moisture to reach and fertilize the egg within the archegonium.

22. (B) Sporophyte
In the life cycle of pteridophytes, the diploid sporophyte is the dominant and prominent generation. It is a long-lived stage differentiated into true roots, stems, and leaves, containing well-developed vascular tissues for transport. Although a haploid gametophyte phase exists, it is typically a small, short-lived, and independent structure that functions primarily to facilitate the process of sexual reproduction.

23. (D) Statement I is incorrect but Statement II is incorrect.
Fossilization is actually an extremely rare occurrence because most organisms decompose or are consumed before they can be preserved. Only a tiny fraction of ancient life is captured in the fossil record. The Geological Time Scale is a standardized system that categorizes Earth's history into hierarchical units like eons and eras, based on significant geological changes and biological transitions.

24. (D) Structure of the sporophyte
The classification of bryophytes into their three primary classes is heavily based on the morphology and complexity of the sporophyte generation. Liverworts typically have simple sporophytes, mosses possess complex capsules with peristome teeth, and hornworts are characterized by elongated, horn-like sporophytes with basal meristems. These structural variations reflect the evolutionary divergent paths taken by each group within the bryophyte division.

25. (C) Megaspore retention protects the female gametophyte.
Heterospory involves the production of two distinct types of spores, representing a significant evolutionary shift. By retaining the megaspore within the parent megasporangium, the plant provides a protected and nutrient-rich environment for the developing female gametophyte. This transition reduced the dependence on external conditions for early development and provided the essential biological framework for the eventual evolution of the seed.

26. (B) Leaves are small, simple, and scale-like (microphylls).
Members of the division Lycopsida are characterized by the presence of microphylls, which are small leaves containing only a single, unbranched vascular vein. This contrasts with the larger, complex megaphylls found in ferns and seed plants. Their stems are typically covered with these small, scale-like leaves, and their

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vascular system is usually a protostele, lacking the gaps associated with megaphylls.

27. (D) Mesozoic Era
The Cycadeoidales, also known as Bennettitales, were a prominent group of gymnosperms that flourished during the Mesozoic Era. They were so abundant during this time that it is often referred to as the age of cycads. This extinct group is famous for its unique flower-like reproductive structures, which have provided researchers with important clues regarding the evolutionary origins of angiosperms.

28. (A) Development of zygotes through syngamy
Bryophytes primarily utilize vegetative methods for asexual reproduction, such as the fragmentation of the thallus or the formation of specialized multicellular bodies called gemmae. These processes allow for rapid colonization without the need for gamete fusion. In contrast, the formation of a zygote through syngamy is the defining event of sexual reproduction, involving the fusion of haploid male and female gametes.

29. (C) Phloem lacks sieve tubes and companion cells, having sieve cells instead.
The vascular anatomy of pteridophytes is less specialized than that of angiosperms. Their phloem tissue contains sieve cells but lacks the more advanced sieve tubes and associated companion cells. Similarly, their xylem consists primarily of tracheids, with true vessels being absent in most species. These anatomical characteristics reflect their evolutionary position as the first land plants to develop a vascular system.

30. (A) Wind (anemophily)
Pollination in gymnosperms is almost exclusively achieved through wind, a process known as anemophily. These plants produce enormous quantities of lightweight pollen grains that are released into the air to be carried to female cones. Many species, such as pines, have evolved specialized structures like wings on their pollen grains to enhance their buoyancy and increase the chances of successful pollination.

31. (D) Simple Hepaticopsida like Riccia
In primitive liverworts such as Riccia, the sporophyte is highly reduced and consists solely of a capsule. It lacks the foot and seta commonly found in more advanced bryophytes. This capsule remains embedded within the gametophytic thallus and is responsible only for producing spores. This simple structure represents the most basic form of sporophytic development within the entire bryophyte division.

32. (B) Aggregations of sporophylls bearing sporangia
A strobilus, or cone, is a specialized reproductive structure found in various vascular plants like Selaginella and Equisetum. it consists of a central axis surrounded by tightly packed sporophylls, which are modified leaves that bear sporangia. These structures function to protect the developing spores and facilitate their efficient dispersal once they reach maturity, marking a significant advancement in reproductive organization.

33. (C) Reduction and simplification of the female gametophyte
A major evolutionary trend in gymnosperms is the progressive reduction of the gametophyte generation. Unlike bryophytes, where the gametophyte is dominant, gymnosperms have a highly reduced female gametophyte that is entirely dependent on the sporophyte. It remains enclosed within the ovule, which provides protection and nourishment, eventually leading to the formation of a seed after the process of fertilization.

34. (D) Ornamental plants and for soil binding
Pteridophytes serve several practical and aesthetic purposes. Many species of ferns are widely cultivated as ornamental plants due to their attractive and diverse foliage. Ecologically, their extensive underground rhizomes and root systems make them excellent soil binders, helping to prevent erosion in moist and sloped habitats. Some species also have medicinal uses or are used as biofertilizers in agriculture.

35. (B) P-3, Q-4, R-1, S-2
Gymnosperms are classified into several orders based on their morphological and reproductive traits. Pinus belongs to Coniferales, characterized by needle-like leaves and cones. Cycas is a member of Cycadales, featuring a palm-like habit. Ginkgo biloba is the sole living representative of Ginkgoales. Gnetum belongs to

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Gnetales, an advanced group that exhibits some anatomical similarities to angiosperms, such as xylem vessels.

36. (D) Haploid gametophyte
The prominent green, leafy plant typically recognized as a moss is the haploid gametophyte generation. This phase is the dominant and independent stage of the life cycle, responsible for photosynthesis and the production of gametes. The diploid sporophyte, which grows upon the gametophyte, is a separate stage that remains physically attached and depends on the leafy gametophyte for its nutrition.

37. (B) Retention of the megaspore inside the megasporangium
The origin of the seed habit is fundamentally linked to the retention of the megaspore within the megasporangium. In certain heterosporous pteridophytes, the megaspore does not leave the parent plant but germinates internally to form the female gametophyte. This protection, combined with the development of an integument, provided the necessary biological conditions for the evolution of seeds in land plants.

38. (A) Horsetails
Members of the class Sphenopsida are commonly known as horsetails due to the unique appearance of their branched stems. They are characterized by jointed stems with distinct nodes and internodes, where small, scale-like leaves are arranged in whorls. Their cell walls often contain silica, giving the plants a gritty texture, which historically led to their use as "scouring rushes" for cleaning.

39. (A) Both A and R are true and R is the correct explanation of A.
The Gnetales are considered the most advanced gymnosperms because they share several significant anatomical and reproductive features with angiosperms. Most notably, they possess true vessels in their xylem, which enhances water transport efficiency. Additionally, some members exhibit a process similar to double fertilization and have floral-like reproductive structures, suggesting a close evolutionary link between gymnosperms and the flowering plants.

40. (A) P. N. Mehra
Professor P. N. Mehra was a distinguished Indian botanist who conducted extensive research on the morphology, cytology, and evolutionary history of Indian gymnosperms. His work particularly focused on the diverse species of conifers and cycads found in the Himalayan region. Through his detailed studies, he contributed significantly to our understanding of the reproductive biology and taxonomic classification of these plants.

41. (B) Aid in the dispersal of spores
In the liverwort Marchantia, the capsule contains specialized sterile cells known as elaters. These cells are characterized by spiral wall thickenings and are highly hygroscopic, meaning they change shape in response to humidity. As the capsule matures and dries, the twisting movements of the elaters help to loosen the spore mass and propel the spores out, ensuring their effective dispersal.

42. (B) 1 and 3 only
Pteridophytes are categorized as vascular cryptogams because they possess specialized conducting tissues but reproduce via spores rather than seeds or flowers. This group encompasses diverse plants such as ferns, horsetails, and club mosses. Unlike bryophytes, the sporophyte in pteridophytes is the dominant generation and becomes independent of the gametophyte shortly after its early development from the zygote.

43. (D) Carboniferous
The Carboniferous period is famously known as the Age of Ferns due to the massive dominance of pteridophytes in terrestrial ecosystems. During this time, vast swamp forests composed of giant club mosses, horsetails, and ferns covered much of the land. The accumulation and subsequent burial of this enormous amount of plant biomass eventually led to the formation of the world's major coal deposits.

44. (C) Ovules are enclosed within an ovary.
A defining characteristic of gymnosperms is that their ovules are naked, meaning they are borne directly on the surface of megasporophylls and are not enclosed within an ovary. Consequently, they do not produce true fruits. Other features include xylem that typically lacks vessels and a haploid endosperm that forms before fertilization,

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serving as the primary nutritive tissue for the developing embryo.

45. (D) Fronds
The leaves of ferns are commonly referred to as fronds and are typically large, complex, and megaphyllous. They often exhibit a pinnate arrangement and are characterized by circinate vernation, where the young leaves are tightly coiled. These fronds serve dual purposes: they are the primary sites for photosynthesis and also bear the reproductive structures, such as sori, on their lower surfaces.

46. (B) Haploid (n)
The protonema is a juvenile, filamentous stage in the life cycle of mosses that develops directly from a germinating haploid spore. Since spores are produced through meiosis, they are haploid, and any structure resulting from their mitotic division maintains this ploidy level. The protonema eventually produces buds that grow into the mature leafy gametophores, which also remain haploid throughout their life.

47. (C) Psilopsida - True roots and leaves present
The classification of pteridophytes is based on distinct morphological differences. Psilopsida is considered the most primitive group because its members lack true roots and leaves, possessing only a dichotomously branched stem and rhizome. In contrast, Lycopsida features small microphylls, Sphenopsida has jointed stems with whorled leaves, and Pteropsida is characterized by large, complex megaphylls, highlighting the evolutionary diversity within this division.

48. (D) Extinct Paleozoic trees with strap leaves
The Corditales were an important group of extinct gymnosperms that flourished during the Paleozoic Era. These plants were typically tall, woody trees characterized by long, strap-shaped leaves and specialized reproductive structures. They are considered significant in the evolutionary history of seed plants, as they likely share a common ancestry with modern conifers and represent a major lineage of early woody plants.

49. (A) Mat formation preventing erosion and aiding soil creation
Bryophytes play a crucial role as pioneer species in ecological succession. By forming dense, moisture-retaining mats on bare surfaces, they trap dust and organic debris, which gradually contributes to the formation of soil. This mat also provides a stable environment for the germination of other plant seeds and effectively prevents soil erosion by cushioning the impact of falling rain and runoff.

50. (B) Endosporic development
Endosporic development refers to the process where the gametophyte grows entirely within the confines of the spore wall. This condition is characteristic of heterosporous plants and is a critical step toward the evolution of seeds. By remaining within the megaspore, the female gametophyte is protected from environmental hazards and is often nourished by the parent sporophyte, enhancing the chances of successful fertilization.

51. (C) Spore dispersal through a dehiscence mechanism
In most ferns, the sporangium is equipped with a specialized ring of cells called the annulus. These cells have thickened inner and radial walls that respond to changes in moisture levels. As the sporangium dries, the tension created by the annulus causes the thin-walled stomium to rupture, violently ejecting the spores into the air to facilitate their wide dispersal in the environment.

52. (D) Welwitschiales
Welwitschia mirabilis is a remarkable and unique gymnosperm that is the sole representative of the order Welwitschiales. Found only in the Namib Desert, it possesses a massive, woody stem and only two permanent, strap-like leaves that grow continuously throughout its long life. This plant exhibits several unusual features that reflect its extreme adaptation to arid environments and its isolated evolutionary lineage.

53. (C) Statement I is correct but Statement II is incorrect.
Bryophytes reproduce sexually through an oogamous process involving a large, non-motile egg and a smaller, motile male gamete. The male

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gamete, known as an antherozoid, is flagellated and requires a film of water to swim from the antheridium to the archegonium. Therefore, fertilization in bryophytes is entirely dependent on moisture, and wind does not play a role in transporting the male gametes.

54. (B) Vascular tissue (xylem and phloem) of higher plants
Some advanced mosses possess a central conducting strand in their stems that facilitates the transport of water and nutrients. This strand is composed of hydroids, which function like xylem for water conduction, and leptoids, which function like phloem for nutrient transport. While these tissues are simpler than those in vascular plants, they are functionally analogous and represent an early step toward complex conduction.

55. (C) Cycadales and Pteropsida (ferns)
Circinate vernation is a unique pattern of leaf development where the young leaves and leaflets are tightly coiled like a watch spring. This feature is most commonly observed in ferns and certain gymnosperms like Cycas. As the leaf matures, the coil gradually unwinds from the base toward the tip. This mechanism protects the delicate growing apex of the leaf from mechanical damage and desiccation.

56. (D) Eras
The Geological Time Scale is structured into several hierarchical units to organize Earth's history. Eras, such as the Paleozoic, Mesozoic, and Cenozoic, are major divisions that represent significant shifts in biological diversity and geological activity. These eras are further subdivided into periods, which are then broken down into epochs, allowing scientists to precisely date and correlate the appearance and extinction of different plant groups.

57. (A) Ginkgo biloba
Ginkgo biloba is widely recognized as a living fossil because it is the only surviving member of an ancient group of gymnosperms that flourished millions of years ago. It has remained morphologically virtually unchanged for over 200 million years. This tree is characterized by its distinctive fan-shaped leaves and its survival through major geological eras, making it a subject of great evolutionary interest.

58. (B) Dictyostele
A dictyostele is a specialized type of siphonostele where the vascular cylinder is broken into several discrete, overlapping strands due to the presence of multiple leaf gaps. Each individual vascular strand is referred to as a meristele. this configuration is commonly found in the stems of many advanced ferns and represents an adaptation to accommodate the departure of vascular traces to large megaphyllous leaves.

59. (C) Most members of Hepaticopsida and Anthocerotopsida
In the classes Hepaticopsida and Anthocerotopsida, the gametophytic plant body is often a simple, undifferentiated thallus. This thallus lacks true roots, stems, and leaves, and is typically dorsiventrally flattened. In contrast, members of the class Bryopsida, or mosses, possess a more complex gametophyte that is differentiated into an erect, leafy axis, although they still lack the true vascular tissues found in higher plants.

60. (D) Softwood for timber, paper, and resins
Gymnosperms, particularly conifers, are of immense global economic importance. They are the primary source of softwood, which is extensively used in the construction and furniture industries. Additionally, their wood is the main raw material for producing high-quality paper pulp. These trees also yield valuable resins, turpentine, and oils, which are utilized in various industrial applications, including the manufacture of paints and pharmaceuticals.

61. (C) Seta
The sporophyte of hornworts is unique among bryophytes because it typically lacks a seta. It consists of a basal foot embedded in the gametophyte and an elongated, horn-like capsule. An intercalary meristem located between the foot and the capsule allows for continuous upward growth. This structure also contains a central columella and utilizes pseudo-elaters to assist in the process of spore dispersal.

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62. (B) Multiciliate and motile
The male gametes in pteridophytes, known as antherozoids, are typically characterized by being motile and possessing multiple flagella or cilia. This motility is essential for their reproductive strategy, as they must swim through a film of external water to reach the egg cell located inside the archegonium. This dependence on water for fertilization is a primitive trait shared between bryophytes and most groups of pteridophytes.

63. (B) Fertilization becomes independent of external water.
A significant evolutionary advancement in gymnosperms is the transition to siphonogamy, where fertilization occurs via a pollen tube. Unlike pteridophytes, which require an external film of water for motile sperm, gymnosperms use wind to transport pollen to the ovule. This allows the sperm to reach the egg without needing liquid moisture, enabling these plants to successfully inhabit and reproduce in much drier terrestrial environments.

64. (D) Sphagnum
Peat is a dark, organic material formed from the partial decomposition of plant matter in waterlogged, acidic environments like bogs. The moss Sphagnum is the primary component of peat, as its remains accumulate and are compressed over thousands of years. Peat has significant economic value as a fuel source and is widely used in horticulture to improve soil aeration and water retention.

65. (B) P-2, Q-4, R-1, S-3
Pteridophytes are classified into four classes based on their morphological features. Psilopsida is characterized by a dichotomously branched rhizome and stem. Lycopsida possesses microphylls, which are small, single-veined leaves. Sphenopsida features a jointed stem with nodes and internodes. Pteropsida, which includes the true ferns, is distinguished by large, complex leaves known as fronds, reflecting the diverse evolutionary specializations within this plant division.

66. (C) Heteromorphic alternation of generations with a dominant gametophyte
Bryophytes exhibit a heteromorphic alternation of generations, where the haploid gametophyte and diploid sporophyte are morphologically distinct. In this life cycle, the gametophyte is the dominant, photosynthetic, and independent phase. The sporophyte is smaller and remains permanently attached to the gametophyte, relying on it for mechanical support and varying degrees of nutrition, representing a unique evolutionary strategy among land plants.

67. (B) Selaginella and Equisetum
In certain vascular plants like Selaginella and Equisetum, sporophylls are not scattered but are instead tightly aggregated at the tips of branches to form distinct structures called strobili or cones. These organized clusters protect the sporangia and facilitate the efficient release of spores. This structural organization is a significant reproductive advancement compared to more primitive plants where sporangia are borne on less specialized vegetative leaves.

68. (A) before; haploid (n)
In gymnosperms, the endosperm is a haploid tissue that develops from the female gametophyte before fertilization occurs. It serves as the primary source of nutrition for the developing embryo within the seed. This contrasts sharply with angiosperms, where the endosperm is typically a triploid tissue formed after fertilization through the fusion of a male gamete with two polar nuclei.

69. (B) Both A and R are true but R is not the correct explanation of A.
Most pteridophytes are homosporous, meaning they produce only one type of spore that develops into a bisexual gametophyte. However, the evolution of heterospory in some lineages was a pivotal development that led toward the seed habit. While both statements are scientifically accurate, the fact that some plants are heterosporous does not directly explain why the majority of the group remains homosporous.

70. (A) Anthocerotopsida
The sporophyte capsule of the class Anthocerotopsida contains specialized sterile cells known as pseudo-elaters. Unlike the true elaters found in liverworts, pseudo-elaters are typically multicellular and lack spiral wall thickenings. However, they perform a similar function by using hygroscopic movements to help loosen the spore mass and assist in the

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gradual release and dispersal of spores from the elongated capsule structure.

71. (D) Solenostele
A solenostele is a type of siphonostele characterized by a central pith and a vascular cylinder that is interrupted by leaf gaps. In a solenostele, these leaf gaps do not overlap, resulting in a continuous tube-like arrangement of vascular tissue in any given cross-section. This structure represents an intermediate stage of evolutionary complexity between the simple protostele and the more highly dissected dictyostele.

72. (B) 1 and 3 only
Gymnosperm wood is typically homoxylous, consisting almost entirely of tracheids and lacking true vessels. This structure provides both conduction and mechanical support. Furthermore, resin canals are common features in many species, particularly in the Coniferales, providing protection against herbivores and pathogens. However, their phloem is less advanced than in angiosperms, as it lacks companion cells, possessing only albuminous cells instead.

73. (B) Pteropsida
Pteropsida is the largest and most diverse class within the division Pteridophyta, encompassing the true ferns. These plants are characterized by megaphyllous leaves, commonly called fronds, and the presence of complex stelar structures like dictyosteles. Ferns are widely distributed across various habitats and are distinguished by their unique reproductive structures, known as sori, which are clusters of sporangia found on the underside of their leaves.

74. (C) Cycas
Sago is a starch-rich food product that is commercially extracted from the pith of the stems of certain gymnosperms, particularly species of Cycas. The stem is harvested, and the internal tissue is processed to separate the starch granules. This product is a valuable carbohydrate source in many tropical regions and highlights the diverse economic uses of gymnosperms beyond their value as timber and resins.

75. (D) A small, heart-shaped, photosynthetic thallus
The gametophyte of a typical fern is known as the prothallus. It is a very small, independent, and heart-shaped structure that grows on moist soil. Being photosynthetic, it can produce its own food. The prothallus bears both the male reproductive organs, antheridia, and the female organs, archegonia. This stage is crucial for sexual reproduction, as it provides the site for fertilization and early development.

76. (A) Formation of a pollen tube to carry male gametes
Reproduction in bryophytes is characterized by several primitive traits. They utilize an oogamous strategy where sperm are produced in multicellular, jacketed antheridia and eggs in archegonia. fertilization requires external water because the male gametes must swim to reach the egg. They do not form pollen tubes; this advanced feature, known as siphonogamy, evolved later in gymnosperms and angiosperms to eliminate the need for water.

77. (A) S, R, P, Q
The history of life on Earth is organized into a chronological sequence of geological units. The Precambrian Time is the oldest and longest span, followed by the Paleozoic Era, known for the rise of early land plants. The Mesozoic Era follows, marked by the dominance of gymnosperms and reptiles. Finally, the Cenozoic Era is the most recent, characterized by the diversification of angiosperms and mammals.

78. (B) Selaginella
Selaginella is a well-known example of a heterosporous pteridophyte. Unlike homosporous ferns that produce only one type of spore, Selaginella produces two distinct sizes: microspores and megaspores. This condition of heterospory is considered a critical evolutionary step toward the development of the seed habit, as it involves the specialized production of male and female gametophytes within different types of sporangia.

79. (C) ferns; gymnosperms
The Pteridospermales are an extinct group that represents an important evolutionary transition. Morphologically, they closely resembled true ferns, particularly in their large, complex foliage.

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However, their reproductive strategy was more advanced, as they produced true seeds instead of spores. This unique combination of fern-like vegetative features and gymnosperm-like reproductive organs earned them the common name "seed ferns" among paleobotanists and researchers.

80. (B) The bryophyte sporophyte is dependent on the gametophyte, while the pteridophyte sporophyte is independent.
In bryophytes, the sporophyte is a relatively simple structure that remains permanently attached to and dependent on the gametophyte for its survival. In contrast, the sporophyte in pteridophytes is the dominant generation. Although it begins its life attached to the gametophyte, it quickly develops true roots and leaves, becoming a large, independent, and photosynthetic plant that represents the main body of the organism.

81. (C) Create a mucilaginous substance to attract antherozoids
As the archegonium of a bryophyte matures, the neck canal cells and the ventral canal cell disintegrate. This process produces a mucilaginous substance that often contains chemical signals like sugars or salts. This substance fills the neck of the archegonium and expands, creating a pathway that chemically attracts motile antherozoids and facilitates their entry toward the egg cell for the process of fertilization.

82. (D) A massive stem with two strap leaves
Welwitschia is a highly specialized gymnosperm adapted to the extreme conditions of the Namib Desert. It possesses a short, broad, and woody stem that resembles a massive disc. Throughout its entire lifespan, which can exceed a thousand years, it produces only two true leaves. These strap-like leaves grow continuously from their base and often become split and frayed at the tips due to environmental exposure.

83. (C) Paleobotany
Paleobotany is the specialized branch of botany that focuses on the study of plant fossils preserved in geological strata. By examining these remains, researchers can reconstruct ancient plant communities, track the evolutionary history of different lineages, and understand past climatic changes. This field provides essential evidence for the transitions between major plant groups, such as the move from non-vascular to vascular terrestrial life.

84. (D) Funaria - Bryopsida
Bryophytes are classified into three major classes based on their morphology. Funaria is a representative of the class Bryopsida, commonly known as mosses, which feature an erect, leafy gametophore and a complex sporophyte. In contrast, Riccia and Marchantia belong to the Hepaticopsida (liverworts), while Anthoceros is a member of the Anthocerotopsida (hornworts). Correct classification depends on understanding these fundamental structural and developmental differences.

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85. (A) Dictyostele
A dictyostele is an advanced type of siphonostele where the vascular cylinder is heavily dissected into multiple strands. This occurs because the leaf gaps associated with the departure of vascular traces to the megaphylls are large and overlap with one another. Each separate strand of vascular tissue is called a meristele, and this configuration is common in the rhizomes of many complex fern species.

86. (B) Presence of vessels in the xylem and similarities to angiosperms
The order Gnetales is unique among gymnosperms because its members possess true vessels in their secondary xylem, a feature otherwise characteristic of angiosperms. This group also shows other advanced traits, such as floral-like reproductive structures and a reduced gametophytic phase. These characteristics have led many botanists to consider Gnetales as an evolutionary link or a closely related sister group to the flowering plants.

87. (C) As a major source of timber for construction
Bryophytes are ecologically and economically useful in several ways, such as providing peat for fuel and serving as indicators of air quality due to their sensitivity to pollutants. They are also used in horticulture for soil improvement. However, they are not used for timber because they are small plants that lack secondary wood and the

structural complexity required for building materials.

88. (D) Selaginella and Isoetes
In certain lycophytes like Selaginella and Isoetes, each leaf possesses a small, scale-like outgrowth on its upper surface known as a ligule. The presence of a ligule is a diagnostic feature used to distinguish these "ligulate" members from other lycopsids like Lycopodium, which lack this structure. The functional role of the ligule is still debated, but it is often associated with water secretion or protection.

89. (C) Birbal Sahni
Professor Birbal Sahni was a world-renowned Indian paleobotanist who made monumental contributions to the study of fossil plants. His research helped clarify the evolutionary relationships of ancient gymnosperms and other extinct groups. He founded the Institute of Palaeobotany in Lucknow, which now bears his name, and his work remains a cornerstone for understanding the prehistoric vegetation and geological history of the Indian subcontinent.

90. (A) Lycopodium
In some species of the genus Lycopodium, the gametophyte is a subterranean, non-photosynthetic structure. Because it cannot produce its own food, it enters into a symbiotic relationship with mycorrhizal fungi to obtain the necessary nutrients from the soil. This type of gametophyte is often long-lived and fleshy, contrasting with the green, photosynthetic surface prothalli found in most other groups of pteridophytes.

91. (D) The vascular tissues (xylem and phloem) and pericycle
In vascular plants, the stele is the central core of the root and stem that is responsible for conduction and support. It encompasses all tissues located internal to the endodermis, including the primary xylem, primary phloem, and the pericycle. In some more advanced stelar types, a central pith may also be present. The organization and evolution of the stele are key features in plant classification.

92. (B) Bryopsida
A characteristic feature of the class Bryopsida, or mosses, is the presence of multicellular rhizoids that often have oblique septa. These branched structures serve to anchor the leafy gametophore to the substrate and assist in the absorption of water. In contrast, most liverworts and hornworts possess unicellular and unbranched rhizoids, making this structural difference a key diagnostic tool for identifying these major bryophyte groups.

93. (C) Bisporangiate, with both pollen and ovule-bearing structures in a flower-like arrangement
The extinct order Cycadeoidales, also known as Bennettitales, is famous for its unique reproductive strobili that resembled flowers. These structures were often bisporangiate, meaning they contained both male and female reproductive organs in a single arrangement, surrounded by protective bracts. This sophisticated organization is much more complex than the simple cones found in most other gymnosperms and has been studied for its evolutionary implications.

94. (D) Haploid gametophytic generation
The life history of pteridophytes is defined by an alternation of generations between two morphologically distinct phases. The diploid sporophyte is the dominant, independent plant that produces spores through meiosis. These haploid spores kemudian germinate to form a small, independent gametophyte, which produces gametes. The fusion of these gametes eventually gives rise to a new sporophyte, completing the cycle and maintaining genetic diversity.

95. (A) P-3, Q-4, R-2, S-1
Various plant groups are identified by their unique specialized structures. Marchantia is known for gemma cups used in asexual reproduction. Equisetum produces organized strobili for its spores. Pinus is characterized by resin canals in its tissues, which provide protection. Anthoceros, a hornwort, possesses pseudo-elaters within its sporophyte capsule to aid in spore dispersal. These features are essential for the taxonomic classification of these diverse plants.

96. (B) Psilotum
Psilotum is a living genus that represents the class Psilopsida, which includes some of the most primitive vascular plants. Its sporophyte

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is characterized by a simple body plan consisting of dichotomously branched stems and a subterranean rhizome, but it completely lacks true roots and leaves. This primitive morphology provides important insights into the early evolution of vascular systems and the colonization of land by plants.

97. (C) Moist, shady habitats
While bryophytes have adapted to terrestrial life, they are most successful and diverse in environments that provide consistent moisture and shade. These habitats are essential because bryophytes lack a sophisticated vascular system and a thick cuticle, making them prone to desiccation. Furthermore, they still require an external film of water to facilitate the movement of their motile male gametes for successful sexual reproduction.

98. (D) It allowed for reproduction and dispersal in drier terrestrial environments.
The evolution of the seed was a transformative event that enabled plants to successfully colonize diverse terrestrial habitats. Seeds provide a protective coat for the embryo and a built-in food supply, allowing the plant to remain dormant until favorable conditions arise. Most importantly, the associated evolution of pollen tubes eliminated the need for external water for fertilization, facilitating reproduction in arid environments.

99. (A) Both A and R are true and R is the correct explanation of A.
In the life cycle of mosses like Funaria, the haploid spore does not immediately grow into a mature leafy plant. Instead, it first germinates into a juvenile, filamentous stage called the protonema. This stage is green, branched, and resembles an alga. The protonema then develops small buds that eventually give rise to the erect, leafy gametophores, ensuring a more efficient colonization of the substrate before sexual maturation.

100. (A) Prothallus
In ferns, the haploid gametophyte is a small, independent structure called the prothallus. This thallus is typically heart-shaped and photosynthetic. It serves as the site for sexual reproduction, bearing the male antheridia and the female archegonia. fertilization occurs on the prothallus in the presence of moisture, leading to the development of the zygote, which then grows into the dominant diploid sporophyte generation.

101. (D) Haploid (n)
In gymnosperms such as Pinus, the endosperm is a haploid tissue because it develops directly from the female gametophyte before the process of fertilization occurs. It functions as the primary nutrient-storing tissue that supports the growth of the developing embryo. This is a key distinction from the triploid endosperm found in angiosperms, which is formed after fertilization through a unique process called double fertilization.

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102. (B) 1 and 2 only
The division Bryophyta is correctly subdivided into three classes: Hepaticopsida (liverworts), Anthocerotopsida (hornworts), and Bryopsida (mosses). Each group is defined by specific morphological and sporophytic characteristics. However, horsetails are not bryophytes; they belong to the Pteridophyta class Sphenopsida. This group is characterized by vascular tissue and a dominant sporophyte, making them distinct from the non-vascular, gametophyte-dominant bryophytes.

103. (C) Distinct nodes and internodes with ridges and grooves
The stems of Equisetum are uniquely characterized by a jointed appearance, consisting of distinct nodes and internodes. The surface of the internodes is marked by longitudinal ridges and grooves, which are reinforced with silica. Small, scale-like leaves are arranged in whorls at each node. This specialized morphology, combined with an internal system of canals, distinguishes the Sphenopsida from all other groups of vascular plants.

104. (D) Corditales
Corditales is an important order of extinct gymnosperms that flourished during the Paleozoic Era. These plants were tall, woody trees with strap-like leaves and specialized reproductive structures. While orders like Coniferales, Cycadales, and Gnetales have living representatives today, Corditales are known only from the fossil record. They provide critical

evidence for understanding the early evolution and diversification of woody seed-bearing plants in ancient terrestrial ecosystems.

105. (A) Foot
The sporophyte of a bryophyte is physically attached to the gametophyte throughout its entire existence. This connection is achieved through a specialized structure called the foot, which is embedded deep within the tissue of the gametophore. The foot serves two primary functions: it provides mechanical anchorage for the sporophyte and acts as a conduit for absorbing water and nutrients from the parent gametophytic plant.

106. (B) Sorus
In many ferns, the sporangia are not produced individually but are instead organized into distinct clusters called sori. These sori are typically found on the underside of fertile fronds. Depending on the species, they may be exposed or covered by a protective membrane known as an indusium. The arrangement and shape of these sori are important taxonomic features used to identify and classify different fern families.

107. (C) The wood is dense and pycnoxylic.
The stem of Cycas is characterized by a massive pith and a large cortex, which are used for storing starch. Its wood is described as manoxylic, meaning it is soft, porous, and contains a high proportion of parenchymatous tissue. This contrasts with the pycnoxylic wood found in conifers like Pinus, which is hard, dense, and compact due to a much higher concentration of xylem tracheids.

108. (D) It is a remnant of the haploid archegonial wall.
The calyptra is a protective, hood-like covering that sits atop the developing capsule of a moss sporophyte. It is derived from the expansion of the archegonium wall following fertilization. Since the archegonium is a structure of the gametophyte, the calyptra is genetically haploid tissue. It serves to protect the young sporophyte from desiccation and mechanical damage until the capsule is fully mature and ready for spore release.

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109. (A) Tropical and subtropical regions, often as an epiphyte
Members of the class Psilopsida, such as the genus Psilotum, are primarily found in tropical and subtropical climates. They often grow as epiphytes on the trunks of other plants or in rocky crevices where moisture is available. These primitive vascular plants prefer warm and humid environments, reflecting their evolutionary history as some of the earliest lineages to adapt to terrestrial life while remaining restricted by specific moisture requirements.

110. (A) Cycadales
Among living gymnosperms, the Cycadales are considered to possess the most primitive features. They retain ancestral traits such as large, motile, and multiflagellated male gametes, which require moisture to reach the egg—a characteristic shared with pteridophytes. Their palm-like habit and circinate vernation in young leaves further highlight their ancient lineage, representing a group that has changed relatively little over hundreds of millions of years.

111. (D) The zygote develops into the gametophyte.
In the life cycle of pteridophytes, the zygote is a diploid cell formed by the fusion of gametes. Following fertilization, it undergoes mitotic divisions to develop into the diploid sporophyte generation, which eventually becomes the dominant, independent plant. The haploid gametophyte, or prothallus, is produced from a germinating spore. This alternation ensures that the multicellular sporophyte stage follows the sexual fusion of gametes.

112. (B) Anthocerotopsida
The presence of a single, large, plate-like chloroplast in each cell of the thallus is a unique diagnostic feature of the class Anthocerotopsida, commonly known as hornworts. These chloroplasts also contain a specialized structure called a pyrenoid, which is involved in the synthesis and storage of starch. This cellular anatomy is quite different from that of other bryophyte classes and suggests a distinct evolutionary path for the hornwort lineage.

113. (C) Coniferales
The order Coniferales is of great economic importance as the primary source of resins and

turpentine. These substances are harvested from specialized resin canals found in the wood and leaves of trees like Pinus. Resins are widely used in the manufacturing of varnishes, adhesives, and soaps, while turpentine serves as a valuable solvent in the paint industry. These products represent significant non-timber forest resources derived from gymnosperms.

114. (D) A haploid gamete-producing phase and a diploid spore-producing phase
Alternation of generations is the fundamental life cycle pattern in all land plants. it involves the regular succession between a haploid gametophyte stage and a diploid sporophyte stage. The gametophyte produces gametes through mitosis, which fuse to form a zygote. This zygote grows into the sporophyte, which then produces haploid spores through meiosis. These spores germinate to start the gametophyte phase again, ensuring genetic recombination.

115. (A) Actinostele
An actinostele is a specialized form of protostele where the central core of xylem tissue is not circular but instead has a star-shaped or lobed appearance in cross-section. Phloem is typically found in the regions between the xylem lobes. This configuration represents an evolutionary advancement over the simpler haplostele, providing an increased surface area for the exchange of materials between the xylem and the surrounding tissues.

116. (B) It is represented by a single living species with fan-shaped, dichotomously veined leaves
The order Ginkgoales is unique because it is monotypic, meaning it contains only one living species: Ginkgo biloba. This tree is characterized by distinctive fan-shaped leaves with dichotomous venation. It is often called a living fossil because its ancestors were widespread millions of years ago, yet it has survived to the present day with very little morphological change, making it a subject of significant botanical and evolutionary study.

117. (A) Asexual (vegetative) reproduction
In the liverwort Marchantia, gemmae are specialized multicellular bodies that facilitate asexual or vegetative reproduction. These small, disc-like structures are produced inside specialized containers called gemma cups located on the upper surface of the thallus. When dispersed by raindrops, each gemma can germinate and grow into a new, genetically identical gametophytic plant, allowing for rapid colonization and expansion of the population in suitable moist habitats.

118. (B) The vascular bundles
In the stem of Equisetum, carinal canals are specialized longitudinal channels that form within the vascular bundles due to the disintegration of early-formed protoxylem. These canals are associated with the conduction of water and are a diagnostic anatomical feature of this group. They are distinct from the vallecular canals, which are larger and located within the cortex, highlighting the complex internal organization of these vascular plants.

119. (C) Many ferns are used as ornamental plants.
Pteridophytes, particularly ferns, hold significant economic and aesthetic value worldwide as ornamental plants. Their diverse and attractive frond shapes make them popular in landscaping and indoor gardening. While they are not major sources of timber or staple food for humans, some species like Azolla are important in agriculture as biofertilizers. Their role in soil conservation and as indicators of environmental health also contributes to their overall importance.

120. (D) Formation of seeds
The primary feature that distinguishes gymnosperms from pteridophytes is the production of seeds. while both groups have vascular tissues and a dominant sporophyte generation, pteridophytes reproduce via spores and lack seeds. Gymnosperms represent a more advanced evolutionary stage where the embryo is protected within a seed, allowing for better survival and dispersal. This advancement was critical for the dominance of seed plants in diverse terrestrial environments across the globe.

121. (A) Anthocerotopsida
The class Anthocerotopsida, commonly known as hornworts, is named for its distinctive sporophyte. This structure is elongated, horn-like, and remains attached to the thalloid gametophyte at its base. Unlike other bryophytes, the hornwort sporophyte possesses an intercalary meristem

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that allows it to grow continuously from the base. This capsule also features photosynthetic tissue and stomata, making it more complex and somewhat more independent than those of liverworts.

122. (B) Mosses
In the life history of mosses, the germination of a haploid spore leads to the formation of a juvenile, filamentous stage known as the protonema. This stage is photosynthetic and resembles green algae. Eventually, small buds develop on the protonema and grow into the mature, erect, leafy plants called gametophores. This two-stage gametophytic development is a defining characteristic of the class Bryopsida and is not found in liverworts or hornworts.

123. (C) Hard, dense, and compact with a large amount of xylem tracheids
The wood of Pinus is described as pycnoxylic because it is extremely dense and hard. This compactness is due to a high concentration of xylem tracheids and a minimal amount of parenchymatous tissue. In a cross-section, the vascular tissue appears solid and tight, which provides significant mechanical strength to the tree. This type of wood is characteristic of conifers and makes them highly valuable for timber and industrial construction purposes.

124. (D) Rhizoid
In a typical moss, the sporophyte generation is composed of three main parts: the foot, which anchors it; the seta, which is a long stalk; and the capsule, where spores are produced. Rhizoids are not part of the sporophyte; instead, they are structures of the gametophyte phase. They function to anchor the haploid plant and absorb water from the substrate, representing a different stage in the alternating generations of the life cycle.

125. (A) P-3, Q-2, R-4, S-1
The dominance of different plant groups correlates with specific periods in geological time. Pteridophytes were most abundant during the Carboniferous, forming massive swamp forests. The Jurassic was dominated by gymnosperms, often called the age of cycads. Early land plants first appeared significantly in the Silurian. Finally, the Quaternary is characterized by the widespread dominance of angiosperms, or flowering plants, which are the most diverse group in modern ecosystems.

126. (B) It is the dominant, long-lived phase of the life cycle.
In pteridophytes, the gametophyte, or prothallus, is a small, short-lived, and inconspicuous structure. Although it is free-living and photosynthetic, it is not the dominant phase of the life cycle. Instead, the diploid sporophyte is the prominent, long-lived generation that forms the main plant body. The prothallus exists primarily to facilitate sexual reproduction by producing gametes in archegonia and antheridia, eventually giving rise to a new sporophyte.

127. (C) Ephedrales
The medicinal drug ephedrine is obtained from various species of the genus Ephedra, which belongs to the gymnosperm order Ephedrales. This compound has historically been used as a potent bronchodilator to treat asthma and as a nasal decongestant. The order Ephedrales is unique among gymnosperms due to its Gnetalian characteristics and its adaptation to arid environments, highlighting the significant pharmacological value that some gymnosperm lineages provide to humans.

128. (D) Liverwort rhizoids are unicellular/unbranched; moss rhizoids are multicellular/branched.
One of the key morphological differences between liverworts and mosses lies in the structure of their rhizoids. In most liverworts, rhizoids are simple, unicellular, and unbranched structures that anchor the thallus. Mosses, belonging to the class Bryopsida, possess more complex, multicellular, and often branched rhizoids that frequently have oblique septa. This anatomical distinction is an important diagnostic feature used by botanists to classify and identify various specimens within the bryophyte division.

129. (A) Both A and R are true and R is the correct explanation of A.
The leaves of the division Lycopsida are termed microphylls due to their simple anatomical structure. A microphyll is typically a small leaf that contains only a single, unbranched vascular vein or trace. Because this vascular trace

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departs from the stem's stele without leaving an interruption in the vascular tissue, it does not create a leaf gap. This simple arrangement is a primitive feature that distinguishes lycophytes from plants with complex megaphylls.

130. (B) Nitrogen-fixing cyanobacteria (e.g., Anabaena)
Cycas plants possess specialized, dichotomously branched roots known as coralloid roots that grow near the soil surface. These roots have a distinctive algal zone in the cortex that hosts symbiotic, nitrogen-fixing cyanobacteria, such as Anabaena cycadae. This relationship is mutually beneficial, as the bacteria provide fixed nitrogen to the plant in exchange for carbohydrates and protection. This adaptation allows Cycas to thrive in soils that are often poor in essential nitrogen.

131. (C) Psilopsida
The class Psilopsida includes the most primitive vascular plants, such as the genus Psilotum. Their sporophyte consists of a dichotomously branched aerial stem and a subterranean rhizome, but it lacks true roots and leaves. Small, scale-like appendages are present instead of leaves. This simple body plan represents an early stage in the evolution of vascular plants, providing a living model for understanding the transitions that occurred during the colonization of land.

132. (A) 1 and 2 only
Gymnosperms are heterosporous seed plants, meaning they produce two types of spores: microspores and megaspores. These spores develop into reduced male and female gametophytes. The union of gametes results in a zygote that develops into a seed. Unlike bryophytes, the dominant generation in gymnosperms is the diploid sporophyte. The gametophytic phase is highly reduced and dependent on the sporophyte for its nutrition, making the sporophyte the prominent and long-lived stage.

133. (A) Meiosis
In the capsule of a moss sporophyte, the sporogenous tissue consists of diploid cells that function as spore mother cells. These cells undergo meiosis, a reductive cell division, to produce haploid spores. This process is essential for the alternation of generations, as it transitions the life cycle from the diploid sporophytic phase back to the haploid gametophytic phase. The resulting haploid spores are kemudian dispersed to germinate and form new gametophytes.

134. (B) Serving as soil binders and mineral indicators
Pteridophytes play significant ecological roles in various terrestrial ecosystems. Many species have extensive root and rhizome systems that effectively bind the soil, preventing erosion in sloped and moist areas. Additionally, certain groups are known to accumulate specific minerals from the soil, acting as biological indicators for the presence of elements like gold or copper. Their role in primary production and as habitat for diverse micro-organisms further contributes to their ecological importance.

135. (C) Soft, porous, and has a large amount of parenchyma tissue
The wood of Cycas is described as manoxylic because it has a relatively loose and porous structure. It contains a large proportion of parenchymatous tissue interspersed with vascular elements, resulting in soft wood that is not commercially valuable for timber. This contrasts with the compact, tracheid-rich pycnoxylic wood of conifers. The manoxylic nature of the wood is often associated with the large pith and cortex characteristic of the cycad stem.

136. (D) The sporophyte is the dominant, independent generation.
In the class Psilopsida, the life cycle follows the general pattern of vascular plants where the diploid sporophyte is the dominant and independent phase. Although it has a simple structure lacking true roots and leaves, the sporophyte is long-lived and photosynthetic. The haploid gametophyte is a small, subterranean, and non-photosynthetic structure that often lives saprophytically with the aid of fungi. This alternation of generations illustrates the evolutionary shift toward sporophyte dominance.

137. (B) R, P, S, Q
The evolution of the seed habit was a multi-step process. It began with the development of heterospory, followed by the retention of the megaspore within the megasporangium. Subsequently, only one functional megaspore was produced per sporangium to concentrate

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resources. Finally, a protective integument evolved around the megasporangium, transforming it into an ovule. These changes together ensured the protection and successful dispersal of the embryo in diverse and often dry environments.

138. (B) In the venter of the archegonium
In bryophytes, sexual reproduction involves the fusion of an egg and an antherozoid. The egg cell is located within the swollen basal portion of the archegonium, known as the venter. When fertilization occurs, the resulting diploid zygote remains inside the venter to undergo initial development into an embryo. This protected environment within the gametophytic tissue is essential for the early stages of the sporophyte's life before it matures and produces spores.

139. (C) Indusium
A sorus is a cluster of sporangia found on the lower surface of a fern frond. In many species, this cluster is protected during its development by a thin, specialized flap of tissue known as an indusium. The indusium helps prevent the delicate sporangia from drying out prematurely. Once the spores are mature, the indusium typically shrivels or falls away, allowing the sporangia to open and release the spores for dispersal.

140. (D) Unicellular, unbranched rhizoids
Members of the class Bryopsida, or mosses, are characterized by a more complex body plan than other bryophytes. Their gametophyte consists of an erect axis with leaf-like structures and is anchored by multicellular, branched rhizoids that often have oblique septa. Unicellular and unbranched rhizoids are typical of liverworts and hornworts. Mosses also feature a distinctive protonema stage and a sporophyte with a well-developed foot, seta, and complex capsule for dispersal.

141. (A) Gymnosperms
While the Mesozoic Era is famously associated with the rise and dominance of reptiles, it was also a time when gymnosperms were the most prominent group of plants on Earth. This era is sometimes called the "Age of Cycads" due to the extreme abundance and diversity of cycad-like plants. Conifers and Ginkgoes also flourished during this time, creating vast forests that supported a wide variety of terrestrial life before the rise of flowering plants.

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142. (B) Morphological and reproductive studies by Indian botanists
Botanical research on gymnosperms in India has a long and rich history. Prominent Indian scientists have focused extensively on the detailed morphological, anatomical, and reproductive characteristics of native species. These studies have provided a deep understanding of the embryology and life cycles of diverse Indian gymnosperms, particularly those found in the Himalayan regions. This foundational research remains essential for the taxonomic classification and evolutionary study of these ancient seed plants.

143. (C) Selaginella
In the genus Selaginella, the sporangia often exhibit internal structures called trabeculae. These are elongated, rod-like cells that traverse the air space within the sporangium or sometimes the stem's cortex. They function as supportive bridges that may also assist in the transport of nutrients. The presence of trabeculae is a specialized anatomical feature that helps identify this genus within the class Lycopsida, reflecting its unique structural complexity among the vascular cryptogams.

144. (D) The gametophyte
In bryophytes, the gametophyte is the dominant and independent phase of the life cycle. It is responsible for various forms of asexual reproduction, which allow the plant to colonize new areas rapidly without the fusion of gametes. Common methods include the fragmentation of the thallus or the production of specialized vegetative structures like gemmae. Because the gametophyte is photosynthetic and long-lived, it serves as the primary stage for population expansion in moist habitats.

145. (A) Microphylls have single veins; megaphylls have complex veins and gaps
The fundamental difference between microphylls and megaphylls lies in their vascular anatomy. Microphylls, found in lycophytes, are small leaves containing only a single, unbranched vascular vein that does not create a gap in the stem's stele.

In contrast, megaphylls, found in ferns and seed plants, are typically larger and have a complex network of branching veins. Their vascular traces are associated with distinct leaf gaps in the vascular cylinder of the stem.

146. (B) Sphenopsida
The plant described possesses the classic morphological features of the class Sphenopsida, commonly represented by Equisetum. These features include jointed stems with distinct nodes and internodes, whorls of small, scale-like leaves at each node, and the presence of a terminal reproductive strobilus. This unique architectural plan, combined with the presence of silica in the epidermis, clearly distinguishes the horsetails from other groups of vascular plants like ferns or club mosses.

147. (C) Cycas (Sago Palm)
Coniferales is an order of gymnosperms that includes trees like Pinus (pine), Cedrus (cedar), and Abies (fir), which typically produce seeds in cones and have needle-like or scale-like leaves. Cycas, although it looks somewhat like a palm, belongs to the order Cycadales. Cycads are distinguished by their stout trunks and large, pinnately compound leaves, representing a different evolutionary lineage with distinct reproductive characteristics compared to the conifers.

148. (D) Paleobotany
Paleobotany is the scientific discipline dedicated to the study of ancient plant remains or fossils. By analyzing these records, paleobotanists can trace the evolutionary lineage of modern plant groups and reconstruct past terrestrial ecosystems and climates. This field is essential for understanding the historical diversification of plants, such as the emergence of vascular tissues and the development of the seed habit, providing a chronological framework for the history of life on land.

149. (A) Hepaticopsida - Sphagnum
The classification of bryophytes is based on distinct morphological and developmental traits. Sphagnum is a unique moss that belongs to its own order within the class Bryopsida, not Hepaticopsida. Hepaticopsida includes liverworts like Marchantia, while Anthocerotopsida consists of hornworts like Anthoceros. Mosses like Funaria and Sphagnum are characterized by a leafy gametophore and a complex sporophyte structure, distinguishing them clearly from the thalloid or leafy liverworts and the horn-like hornworts.

150. (B) A vascular cylinder with a central parenchymatous pith
A siphonostele represents an advanced stelar architecture where the vascular tissues are arranged in a cylinder around a central core of parenchyma. This central region is known as the pith and serves functions related to storage and structural support. This configuration differs significantly from the more primitive protostele, which has a solid core of xylem and completely lacks any central pith tissue, illustrating an evolutionary trend toward increasing complexity.

151. (C) A subterranean rhizome with branched shoots; roots are absent
The class Psilopsida contains some of the most primitive living vascular plants. Their body plan is remarkably simple, consisting of a subterranean rhizome and aerial, dichotomously branched stems. A key characteristic is the complete absence of true roots; instead, the rhizome utilizes hair-like rhizoids for absorption. They also lack true leaves, having only small, scale-like appendages. This primitive morphology provides a window into the early stages of vascular plant evolution on land.

152. (A) Both Statement I and Statement II are correct.
The life cycles of pteridophytes and gymnosperms show different levels of gametophyte development. In pteridophytes, the gametophyte is usually a small, heart-shaped, and independent structure called a prothallus. In gymnosperms, the evolutionary trend toward reduction reaches a point where both male and female gametophytes are extremely small. They are never free-living and remain entirely dependent on and retained within the tissues of the sporophyte for their protection and nutrition.

153. (D) Fern foliage that produced seeds instead of spores
The Pteridospermales are a fascinating extinct group that bridges the gap between ferns and gymnosperms. While they possessed large,

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complex, and highly divided leaves that were morphologically identical to fern fronds, they reproduced by means of true seeds rather than spores. This combination of "primitive" vegetative traits and "advanced" reproductive strategies earned them the name "seed ferns," highlighting their critical role in the evolution of the seed habit among early land plants.

154. (A) Diploid (2n)
In bryophytes, as in all sexually reproducing organisms, the zygote is formed by the fusion of two haploid gametes: a male antherozoid and a female egg. Because each gamete contributes one set of chromosomes, the resulting zygote is diploid. This single cell marks the beginning of the sporophyte generation. It will kemudian undergo numerous mitotic divisions to develop into the multicellular diploid sporophyte, which remains attached to the parent haploid gametophytic plant body.

155. (B) P-3, Q-1, R-4, S-2
Various botanical terms describe specific stages or structures in different plant groups. Heterospory is the production of two types of spores. The protonema is a juvenile filamentous stage characteristic of mosses. Cycas possesses coralloid roots that host nitrogen-fixing cyanobacteria. The term frond is used to describe the large, complex leaves of ferns. These terms are essential for accurately describing the diverse morphological and life cycle variations found across the plant kingdom.

156. (B) Peat for fuel and in horticulture
Sphagnum moss is highly significant economically because its partially decomposed remains form peat. In many parts of the world, peat is harvested and dried for use as a fuel source. In horticulture, Sphagnum and peat are valued for their exceptional ability to retain moisture and improve soil aeration. These properties make them ideal for the trans-shipment of live plants and as a growing medium for moisture-loving species like orchids and ferns.

157. (C) Lycopsida
Members of the class Lycopsida are commonly referred to as "club mosses" or "spike mosses" due to their small, scale-like leaves and the cone-like strobili produced at the tips of their stems. Despite their common name, they are not true mosses but are vascular plants. They represent an ancient lineage that reached massive sizes during the Carboniferous period but is mostly represented today by small, herbaceous genera like Lycopodium and Selaginella.

158. (D) Pinus
In the genus Pinus, the pollen grains are uniquely characterized by the presence of two air-filled sacs or wings. These structures are derived from the outer layer of the pollen wall and serve to increase the buoyancy of the pollen grain in the air. This is an adaptation to wind pollination, or anemophily, allowing the pollen to be carried efficiently over long distances from the male cones to the female ovules.

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159. (A) Both A and R are true and R is the correct explanation of A.
Gymnosperms are classified as phanerogams, meaning they produce seeds, but they are distinguished from angiosperms by the absence of an ovary. Their ovules are described as "naked" because they are borne directly on the surface of megasporophylls, exposed to the environment. This lack of an enclosing ovary wall means that gymnosperms do not produce true fruits; the seeds develop directly on the scale of the cone following the process of fertilization.

160. (A) A dominant, independent sporophyte and a reduced, independent gametophyte
The life history of Lycopsida follows the typical pattern for vascular cryptogams. The prominent, long-lived plant body is the diploid sporophyte, which is differentiated into true roots, stems, and leaves. During reproduction, it produces spores that germinate into a small haploid gametophyte. This gametophyte is independent and free-living, although it is much smaller and less conspicuous than the sporophyte, serving primarily as the site for the production and fusion of gametes.

161. (C) Sporophyte with an intercalary meristem providing continuous growth
A unique and defining feature of the class Anthocerotopsida, or hornworts, is the presence of an intercalary meristem at the base of the sporophyte capsule. This meristematic tissue allows the sporophyte to grow continuously from its base, pushing the mature parts upward. This

results in the characteristic horn-like shape and a gradient of development within a single capsule. This continuous growth mechanism is not found in the sporophytes of liverworts or mosses.

162. (D) 3 → 1 → 2
The life cycle of a fern begins with the release of haploid spores from mature sporangia. These spores germinate on moist soil to form the independent, heart-shaped prothallus. On this gametophyte, male and female gametes are produced and fuse through the process of fertilization when water is present. The resulting diploid zygote kemudian begins to divide and develop into the young sporophyte, which eventually grows into the large, prominent fern plant we commonly recognize.

163. (A) The organic material has been replaced by minerals, preserving the detailed cellular structure.
Petrifaction is a remarkable process of fossilization where mineral-rich water infiltrates the cells and tissues of a dead organism. Over time, the original organic material is gradually replaced molecule by molecule with minerals like silica or calcium carbonate. This replacement is so precise that the internal cellular details and even microscopic structures are preserved in stone. Petrifactions are invaluable to paleobotanists for studying the internal anatomy of extinct plant species.

164. (B) Cycadales and Ginkgoales
In the gymnosperm orders Cycadales and Ginkgoales, the male gametes are large, multiflagellated, and motile. This is considered a primitive or ancestral feature because it resembles the sperm of pteridophytes and bryophytes. Even though these gymnosperms utilize pollen tubes to deliver the sperm to the ovule, the sperm themselves still retain the ability to swim through a small amount of fluid inside the ovule to reach the egg cell for fertilization.

165. (C) Spore dispersal
In the class Bryopsida, the mouth of the sporophyte capsule is surrounded by specialized structures called peristome teeth. These teeth are highly hygroscopic, meaning they bend and move in response to changes in environmental humidity. These movements act as a mechanical gate, allowing spores to be released only when the air is dry, which is ideal for wind dispersal. This sophisticated mechanism ensures that spores are scattered efficiently to increase the chances of colonization.

166. (B) The departure of a vascular trace to a megaphyll
A leaf gap is a localized interruption in the vascular cylinder of a stem's stele. It occurs immediately above the point where a vascular trace branches off to enter a megaphyll. This anatomical feature is characteristic of advanced vascular plants like ferns and seed plants. Microphylls, by contrast, are served by simple vascular traces that do not create such gaps, reflecting a fundamental difference in the structural complexity between these two types of leaves.

167. (B) A eustele with vascular bundles surrounding a large pith cavity, and carinal/vallecular canals
The stem anatomy of Sphenopsida, such as Equisetum, is highly specialized. It features a ring of vascular bundles arranged around a large central pith cavity, which is often hollow in mature plants. This arrangement is similar to a eustele. uniquely, it also contains specialized longitudinal channels: carinal canals within the vascular bundles and vallecular canals within the cortex. These features are related to water conduction and gas exchange, distinguishing horsetails from other vascular groups.

168. (B) megaspore; megasporangium
The evolution of the seed habit is fundamentally rooted in the retention of the megaspore. Instead of being released into the environment, the megaspore remains and germinates within the megasporangium of the parent sporophyte. This led to the development of the female gametophyte in a protected, nutrient-rich setting. This biological transition, combined with the evolution of protective integuments, provided the foundation for the development of seeds, allowing plants to reproduce successfully in drier environments.

169. (C) Funaria has foot/seta/capsule; Riccia has capsule only
The sporophyte structure varies significantly among bryophytes, reflecting different levels of evolutionary complexity. In the primitive liverwort Riccia, the sporophyte is extremely

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simple, consisting only of a spore-producing capsule embedded in the gametophyte. In contrast, the moss Funaria has a much more advanced sporophyte differentiated into three distinct parts: a foot for anchorage and absorption, a long stalk called the seta, and a complex capsule equipped for sophisticated spore dispersal into the environment.

170. (D) Production of chilgoza nuts from Pinus gerardiana
Gymnosperms provide several valuable food products in addition to their industrial uses. A notable example is the production of "chilgoza" nuts, which are the edible seeds of the pine species Pinus gerardiana. These nuts are highly nutritious and are an important commercial crop in certain mountainous regions. This highlights the diverse economic contributions of gymnosperms, ranging from high-quality timber and industrial resins to specialized food sources used by human populations in specific geographical areas.

171. (C) Usually monoecious, bearing both antheridia and archegonia
The gametophyte of most ferns, known as the prothallus, is typically monoecious or homothallic. This means that a single, heart-shaped thallus produces both the male reproductive organs, antheridia, and the female organs, archegonia. This arrangement facilitates the process of fertilization on the same plant body, although environmental factors may sometimes encourage cross-fertilization. The prothallus remains small and independent, providing the necessary platform for the sexual phase of the fern's life cycle in moist habitats.

172. (D) Gymnospermae
The division Gymnospermae is defined by the production of naked seeds. Unlike angiosperms, where the ovules are enclosed within an ovary that later develops into a fruit, gymnosperm ovules are borne directly on the surface of megasporophylls or cone scales. Consequently, the seeds remain exposed throughout their development. This characteristic is the primary feature used to distinguish gymnosperms from the flowering plants, representing an earlier evolutionary stage of seed-producing terrestrial vegetation across the globe.

173. (A) Lycopsida
Bryophytes are non-vascular plants divided into three classes: Hepaticopsida (liverworts), Anthocerotopsida (hornworts), and Bryopsida (mosses). Lycopsida is not a class of bryophytes; it is a class within the division Pteridophyta. Lycopsids are vascular plants characterized by the presence of xylem, phloem, and microphyllous leaves. This distinction is fundamental in plant classification, separating the more primitive non-vascular land plants from those that have developed specialized tissues for the conduction of water and organic nutrients.

174. (B) Protostele (haplostele or siphonostele in different species)
In the genus Selaginella, the vascular anatomy of the stem is typically a protostele, which is the most primitive stelar type. In some species, this may be a simple haplostele with a solid core of xylem. in others, it can develop into a siphonostele or even exhibit multiple stelar strands. This diversity in stelar structure within a single genus highlights the evolutionary transitions and the range of anatomical complexity found among the members of the class Lycopsida.

175. (C) A monotypic and geographically restricted lineage
Welwitschia mirabilis is a remarkable gymnosperm that is the sole living representative of its order, Welwitschiales. It is endemic to a very specific and narrow geographic range within the Namib Desert of southwestern Africa. This combination of being monotypic and highly restricted illustrates an evolutionary lineage that has survived in extreme isolation. Its unique morphology and physiology are highly specialized for desert survival, making it one of the most unusual and scientifically significant plants on Earth.

176. (D) Water is necessary for the motile antherozoids to swim to the egg.
Despite their adaptation to land, bryophytes still rely on an ancestral reproductive mechanism that requires liquid water. The male gametes, known as antherozoids, are flagellated and motile. To achieve fertilization, they must be released into a film of moisture on the plant surface and swim to the neck of the archegonium to reach the egg. This fundamental requirement for external

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water limits bryophytes to moist habitats and distinguishes their reproductive biology from the more advanced seed-producing plants.

177. (A) Haploid gametophyte
The term "alternation of generations" refers to the life cycle pattern where a diploid sporophyte phase alternates with a haploid gametophyte phase. In Psilopsida, the prominent, branched structure is the diploid sporophyte. It produces haploid spores through the process of meiosis. These spores kemudian germinate to form a small, haploid gametophyte, which is often subterranean and produces the gametes. This cycle ensures genetic recombination and is a universal characteristic of all land plants, from bryophytes to angiosperms.

178. (B) Evolution of the pollen tube for fertilization
A major evolutionary leap from pteridophytes to gymnosperms is the development of the pollen tube, a process known as siphonogamy. In pteridophytes, motile sperm require external water to swim to the egg. In gymnosperms, the male gametophyte is delivered by wind as a pollen grain. Upon landing near the ovule, it grows a tube that carries the sperm directly to the egg. This eliminated the need for liquid moisture for fertilization, allowing these plants to colonize dry environments.

179. (C) Hepaticopsida
A Bryophyte specimen with a dorsiventrally flattened thallus and unicellular rhizoids is characteristic of the class Hepaticopsida, commonly known as liverworts. These plants typically have a prostrate growth habit and lack the erect, leafy appearance of mosses. Their rhizoids are simple tubes that function for anchorage and absorption. While some liverworts are leafy, many prominent genera like Marchantia and Riccia exhibit this thalloid morphology, which is a key diagnostic feature for this class.

180. (D) Increasing structural support and more efficient transport
The evolution of stelar architecture from the simple, solid protostele to the complex eustele represents a significant trend toward improved functionality. More advanced stelar types allowed for a more efficient distribution of vascular tissues and the development of a central pith for storage. This increased complexity provided better mechanical support and enhanced the capacity for transporting water and nutrients, which was essential for the evolution of larger plant bodies and the diversification of terrestrial vegetation.

181. (A) sporophyte
In the class Lycopsida, which includes club mosses and spike mosses, the prominent and dominant generation is the sporophyte. This plant body is highly organized and differentiated into true roots, stems, and leaves, containing a well-developed vascular system for conduction. This represents a significant evolutionary advancement over bryophytes. The gametophyte in this group is a separate, much smaller, and often short-lived structure that functions only to produce the gametes required for the next sporophytic generation.

182. (B) Close evolutionary relationship to modern Gnetum
The extinct order Cycadeoidales, also known as Bennettitales, is characterized by several distinct features, including pinnately compound leaves and unique, flower-like bisporangiate strobili. While they shared some morphological similarities with modern cycads, such as their leaf structure and stomata, they are not considered to have a close evolutionary relationship with the genus Gnetum. Gnetum belongs to the Gnetales, which possess xylem vessels and other advanced traits not found in the Bennettitales.

183. (C) They are found worldwide, but prefer damp and shady places.
Bryophytes are a globally distributed group of plants found on every continent, including Antarctica. However, due to their lack of a sophisticated vascular system and their requirement for water during sexual reproduction, they are most abundant and diverse in moist, temperate, and tropical regions. They thrive in damp, shady environments such as forest floors, riverbanks, and wetlands, where they can maintain hydration and successfully complete their life cycles in the presence of consistent moisture.

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184. (D) Allow reproduction/dispersal in drier terrestrial regions
The combination of heterospory and the development of the seed habit provided land plants with a massive adaptive advantage. By producing specialized microspores and megaspores, and kemudian retaining the embryo within a protected seed, these plants became less dependent on humid conditions. The evolution of wind-dispersed pollen and the self-contained nutrient supply within the seed allowed these lineages to colonize and reproduce in arid terrestrial environments where non-seed-bearing plants like bryophytes and pteridophytes struggle to survive.

185. (A) P-3, Q-4, R-1, S-2
Plant classification is based on placing specific genera into their respective classes or orders. Equisetum is the primary representative of the Sphenopsida. Pinus is a well-known member of the Coniferales. Anthoceros is a diagnostic genus for the class Anthocerotopsida, characterized by its horn-like sporophyte. Selaginella is a prominent genus within the Lycopsida, notable for being heterosporous. Matching these examples to their correct taxonomic groups is essential for understanding the diversity and evolution of the plant kingdom.

186. (B) They form a carpet on the forest floor, retaining moisture and preventing soil erosion.
Bryophytes play a vital ecological role in forest ecosystems by forming dense, moisture-absorbing mats on the ground and on tree trunks. These carpets act like sponges, trapping rainwater and slowly releasing it, which helps maintain high humidity levels within the forest. Additionally, their dense growth anchors the topsoil and organic matter, significantly reducing the risk of soil erosion caused by heavy rainfall and runoff, while providing a habitat for diverse microorganisms and invertebrates.

187. (C) Small, free-living gametophyte (prothallus)
The life history of the Sphenopsida, represented by horsetails like Equisetum, involves an alternation of generations between a dominant sporophyte and a reduced gametophyte. The sporophyte is the prominent plant with jointed stems and vascular tissue. The spores it produces germinate into a small, independent, and photosynthetic prothallus. This gametophyte is usually only a few millimeters in size and produces the antheridia and archegonia, facilitating sexual reproduction before a new sporophyte begins to grow.

188. (D) Gnetales
Gnetales is a specialized and advanced group of gymnosperms that includes the genera Gnetum, Ephedra, and Welwitschia. Unlike other gymnosperms whose xylem is composed almost entirely of tracheids, members of the Gnetales possess true vessels in their secondary wood. This anatomical feature is much more typical of angiosperms and suggests an evolutionary trend toward more efficient water conduction. This, along with other shared traits, has made Gnetales a subject of intense study regarding the origin of flowering plants.

189. (A) Both A and R are true and R is the correct explanation of A.
Pteridophytes are frequently referred to as vascular cryptogams because they occupy a unique evolutionary position. They were the first group of terrestrial plants to develop specialized vascular tissues, xylem and phloem, for the efficient transport of water and nutrients. However, like other cryptogams, they do not produce flowers or seeds; instead, they reproduce through the formation of spores. This combination of “advanced” vascularity and “primitive” spore-based reproduction is the defining characteristic of this diverse plant division.

190. (B) The use of Azolla as a biofertilizer in rice paddies.
Azolla is a small, aquatic pteridophyte of great economic importance in agriculture. It has a symbiotic relationship with the nitrogen-fixing cyanobacterium Anabaena azollae, which lives in specialized cavities within its leaves. Because of this partnership, Azolla can fix significant amounts of atmospheric nitrogen. Farmers widely use it as a green manure or biofertilizer in rice paddies, where it enriches the soil with nitrogen, significantly increasing crop yields and reducing the need for chemical fertilizers.

191. (C) A dominant, independent sporophyte with large, complex leaves (fronds)
The defining feature of the life cycle in the class Pteropsida, which includes the true ferns,

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is the dominance of the diploid sporophyte. This stage is the prominent plant we observe in nature, characterized by well-developed vascular tissues and large, complex megaphyllous leaves known as fronds. While they also produce a small, independent gametophytic prothallus, the sporophyte is the long-lived and most structurally complex phase, responsible for both photosynthesis and the production of spores for dispersal.

192. (B) 2 and 3 only
Gymnosperm reproduction is characterized by several advanced features that distinguish them from more primitive plants. The pollen grain represents the highly reduced male gametophyte, which is dispersed by wind. Following successful pollination and fertilization, the ovule develops into a seed, which contains the embryo and a food supply. Unlike bryophytes and many pteridophytes, most gymnosperms have evolved siphonogamy, using a pollen tube to deliver sperm, thereby eliminating the absolute requirement for external water for fertilization.

193. (A) Gemma cups
Marchantia, a well-known liverwort, has evolved specialized structures called gemma cups for the purpose of asexual reproduction. These small, cup-shaped organs are located on the dorsal surface of the thallus and contain numerous multicellular, lens-shaped bodies called gemmae. When raindrops splash into the cups, the gemmae are dispersed into the surrounding environment. Each dispersed gemma is capable of germinating and growing into a new gametophytic plant that is genetically identical to the parent thallus.

194. (B) The development of large, complex leaves (megaphylls) that create leaf gaps in the vascular cylinder
The evolution from a siphonostele to a dictyostele is a structural response to the increasing complexity of leaves. Megaphylls require significant vascular traces that depart from the stem's central cylinder. At each point of departure, an interruption or "leaf gap" is created in the vascular tissue. In plants with large, numerous leaves, these gaps become frequent and overlap, causing the original cylinder to break into a network of separate vascular strands, a configuration known as a dictyostele.

195. (C) Pteridospermales (Seed Ferns)
The Pteridospermales, commonly known as seed ferns, are an entirely extinct group of gymnosperms that were widespread during the Paleozoic and Mesozoic Eras. They are of immense evolutionary importance because they possessed vegetative characteristics like true ferns but reproductive structures like gymnosperms. Fossil evidence of this group has provided crucial information about the transition from spore-bearing to seed-bearing plants, illustrating how the seed habit first emerged in lineages with complex, fern-like foliage.

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196. (D) Haploid spores germinate to form a diploid protonema.
In the moss life cycle, haploid spores are produced through meiosis within the sporophyte capsule. When these spores germinate, they undergo mitotic divisions to form the juvenile filamentous stage known as the protonema. because the spores themselves are haploid, the resulting protonema is also haploid. It remains a part of the gametophytic generation and eventually produces buds that grow into the mature leafy gametophores, maintaining the haploid state throughout the entire gametophytic phase of the life cycle.

197. (A) R, S, P, Q
The fossil record provides a chronological sequence for the appearance of major plant groups. Bryophyte-like plants are among the earliest land colonizers. They were followed by the Pteridophytes, which were the first to develop vascular tissues. Gymnosperms emerged next, introducing the seed habit. Finally, Angiosperms appeared most recently and have become the most diverse and dominant group. This progression reflects an increasing adaptation to terrestrial environments through the evolution of vascular systems and sophisticated reproductive strategies.

198. (B) Spore dispersal
In the sporangia of many ferns, the annulus and stomium are specialized parts of the wall that facilitate the release of spores. The annulus is a row of cells with thickened walls that create tension as they dry out. When this tension reaches a critical point, the sporangium ruptures at a specific thin-walled region called the stomium.

This sudden break causes the annulus to snap back, violently ejecting the mature spores into the air to ensure wide dispersal.

199. (C) Yellow, winged pollen grains
"Sulphur showers" are a spectacular phenomenon observed in large pine forests during the spring. Pines are wind-pollinated and produce immense quantities of yellow pollen grains to ensure successful reproduction. many of these grains are equipped with air sacs or wings to help them float. When they are released simultaneously, the air becomes filled with a yellow dust that settles on the ground and water surfaces, resembling a fine dusting of powdered sulphur.

200. (D) True roots
A fundamental characteristic shared by all bryophytes is the complete absence of true roots. instead of roots, they utilize simple hair-like structures called rhizoids for anchorage and absorption. While they may have thalloid bodies or leafy stems and some possess stomata or similar pores for gas exchange, they lack the specialized vascular tissues (xylem and phloem) that are necessary for the development of true roots, stems, and leaves as defined in more advanced vascular plant groups.

201. (A) Sphenopsida
Members of the class Sphenopsida, such as Equisetum, are characterized by the deposition of large amounts of silica in their epidermal cell walls. This provides the plants with significant structural rigidity and a distinctively rough, gritty texture. Because of this abrasive property, these plants were historically used as "scouring rushes" for cleaning metal pots and polishing wood. This mineral deposition is a unique diagnostic feature that distinguishes the horsetails from other groups of pteridophytes.

202. (B) Heterospory
Heterospory is the condition where a plant produces two morphologically different types of spores: small microspores and large megaspores. This feature is prominent in certain pteridophytes like Selaginella. Microspores develop into male gametophytes, while megaspores develop into female gametophytes. This specialization is a critical evolutionary precursor to the seed habit, as it allows for the differentiation of reproductive roles and the internal protection of the developing female gametophyte within the parent sporophyte tissue.

203. (C) Double fertilization is a characteristic feature of all gymnosperms.
While gymnosperms are seed-producing plants with naked ovules and a sporophytic body plan, they do not undergo double fertilization. Double fertilization, which involves the formation of a zygote and a triploid endosperm, is a defining characteristic of angiosperms. in most gymnosperms, a single fertilization event occurs, and the nutritive endosperm is a haploid tissue that develops from the female gametophyte before fertilization. Only a few members of the Gnetales show a process somewhat similar to double fertilization.

204. (D) Anthocerotopsida
The sporophyte of the class Anthocerotopsida, or hornworts, is uniquely structured compared to other bryophytes. It consists of a basal foot and an elongated, horn-like capsule, but it lacks a true seta. A key feature is the presence of an intercalary meristem located between the foot and the capsule, which allows for continuous upward growth throughout the life of the sporophyte. This enables the gradual production and release of spores over an extended period from the maturing tip.

205. (A) A dominant, independent sporophyte generation
A major evolutionary distinction between bryophytes and pteridophytes is the nature of their alternating generations. In bryophytes, the haploid gametophyte is the dominant and independent phase, while the sporophyte is small and dependent. In pteridophytes, the relationship is reversed: the diploid sporophyte is the prominent, long-lived, and independent generation that forms the main plant body. Although pteridophytes still produce a small, independent gametophyte, the sporophyte has become the primary stage adapted for terrestrial survival and dispersal.

206. (B) Reduction of the number of functional megaspores to one per megasporangium
The evolution of the seed habit required several coordinated changes, one of the most important

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being the reduction to a single functional megaspore within the megasporangium. By eliminating competition between multiple megaspores, the parent plant can concentrate all available nutrients and protective resources into a single developing female gametophyte. This ensures that the resulting embryo has the best possible start in life, a strategy that is fundamental to the reproductive success of all modern seed-producing plants.

207. (C) The stele is the central vascular cylinder of the root and stem.
In pteridophytes, the internal anatomy is characterized by the presence of a stele, which is the central cylinder of vascular tissues (xylem and phloem) and associated ground tissues like the pericycle and pith. The organization of the stele varies from simple protosteles to more complex dictyosteles. While they possess vascular tissues, their xylem typically consists only of tracheids and lacks vessels, and they generally show limited secondary growth compared to the extensive wood produced by gymnosperms.

208. (D) Softwood for timber, paper pulp, and resins
The order Coniferales includes some of the most economically valuable plants on Earth. They are the primary source of softwood, which is preferred for construction and furniture due to its strength and workability. Their long fibers are also ideal for manufacturing high-quality paper and cardboard. Furthermore, conifers are a major source of industrial chemicals such as resins, turpentine, and various essential oils, making them a cornerstone of global forestry and manufacturing industries.

209. (A) Morphology of the gametophyte and structure of the sporophyte
The division Bryophyta is classified into three major classes based on fundamental differences in their physical organization. Hepaticopsida (liverworts) often have a thalloid or leafy gametophyte and simple sporophytes. Anthocerotopsida (hornworts) are distinguished by their single-chloroplast cells and horn-like sporophytes with intercalary meristems. Bryopsida (mosses) feature an erect leafy gametophore and a complex sporophyte with a seta and peristome. These structural variations reflect different evolutionary strategies within the non-vascular land plant lineage.

210. (B) Dominant sporophyte, independent gametophyte
In the class Psilopsida, the life cycle follows the characteristic pattern of vascular plants. The diploid sporophyte is the prominent and independent phase, despite its simple body plan lacking true roots and leaves. It produces haploid spores that germinate into a small, independent gametophyte. This gametophyte is often subterranean and obtains its nutrition saprophytically, usually through a symbiotic association with fungi. This alternation of generations illustrates the transition toward the sporophyte-dominant strategy essential for successful terrestrial life.

211. (C) Ginkgoales
The order Ginkgoales is represented today by only a single living species, Ginkgo biloba. It is frequently referred to as a "living fossil" because its morphological features have remained virtually unchanged for over 200 million years, while all other members of its order have become extinct. This tree is easily recognized by its unique fan-shaped leaves and its remarkable resilience, having survived through major geological eras to remain a significant part of modern botanical diversity.

212. (D) Spores from spore mother cells in the capsule
In the life cycle of a moss, the diploid sporophyte contains a specialized tissue of spore mother cells within its capsule. These cells undergo meiosis, which reduces the chromosome number by half to produce haploid spores. This event is the critical transition point from the diploid sporophytic generation to the haploid gametophytic generation. Once mature, these haploid spores are dispersed into the environment, where they can germinate to form the juvenile protonema and start a new gametophyte.

213. (A) Provided structural support and allowed for efficient transport of water and nutrients
The evolution of a vascular system, or stele, was a transformative adaptation that allowed plants to thrive on land. Xylem tissue, with its lignified cell walls, provided the necessary mechanical strength for plants to grow taller and compete for sunlight.

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Simultaneously, it allowed for the efficient long-distance transport of water and minerals from the soil. Phloem facilitated the distribution of sugars produced during photosynthesis, enabling the development of complex, multi-organ plant bodies in diverse terrestrial habitats.

214. (B) Ferns
The class Pteropsida is the largest group within the division Pteridophyta and consists of the true ferns. These plants are characterized by the presence of megaphyllous leaves, commonly called fronds, which are often large and highly divided. They also feature a range of stelar organizations, from siphonosteles to complex dictyosteles. Ferns reproduce via spores produced in specialized structures called sori, usually located on the underside of their leaves, and are widely distributed across various moist and temperate environments.

215. (A) P-3, Q-4, R-1, S-2
Various plant groups are identified by specialized anatomical and morphological features. Funaria, a moss, uses peristome teeth for controlled spore dispersal. Ferns are known for circinate vernation, where young leaves are tightly coiled. Cycas possesses coralloid roots that house nitrogen-fixing cyanobacteria. Selaginella is characterized by a ligule, a small scale-like structure on the upper surface of its leaves. These diagnostic traits are essential for the taxonomic classification and study of diverse plant lineages within botany.

216. (D) Serving as a major source of atmospheric oxygen
Bryophytes are ecologically important as pioneer species that initiate soil formation on bare rocks and prevent erosion by forming dense, moisture-retaining mats. They also serve as sensitive bioindicators of air and water pollution. While they perform photosynthesis and contribute to local oxygen levels, their small size and relatively low total biomass mean they are not a major global source of atmospheric oxygen compared to the vast forests of vascular plants and the phytoplankton in the world's oceans.

217. (A) Cycadales
The order Cycadales includes gymnosperms that exhibit a distinct palm-like growth habit, characterized by a stout, typically unbranched trunk and a crown of large, pinnately compound leaves. These plants are dioecious and produce massive cones. A primitive characteristic they retain is the production of large, multiflagellated, and motile male gametes. This combination of ancient reproductive traits and specific morphological features distinguishes the cycads from other gymnosperm orders like Coniferales or Gnetales.

218. (B) One type of spore that develops into a bisexual gametophyte
In homosporous pteridophytes, such as most ferns and Lycopodium, the sporophyte produces only one kind of spore. All these spores are morphologically identical. Upon germination, each spore grows into a small, independent gametophyte, known as a prothallus, that is typically bisexual. This means it bears both the male antheridia and the female archegonia on the same plant body. This reproductive strategy is common in many primitive vascular plants before the evolutionary development of heterospory.

219. (A) Both A and R are true and R is the correct explanation of A.
Bryophytes represent an early stage in the colonization of land, but they remain poorly adapted to fully terrestrial life due to two primary factors. First, they lack a specialized vascular system (xylem and phloem) for long-distance transport, which limits their size and ability to withstand drying. Second, they are reproductively tied to water; their flagellated male gametes require an external film of moisture to swim to and fertilize the egg, confining them to damp environments.

220. (D) Relate geological strata to time and describe the timing of events in Earth's history
The Geological Time Scale is a fundamental framework used in Earth sciences to organize the history of our planet. It divides time into a hierarchy of units, such as eons, eras, and periods, based on significant geological changes and major biological events like mass extinctions or the appearance of new life forms. This scale allows scientists to correlate rock layers from different locations and provides a chronological context for the evolutionary transitions observed in the fossil record.

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221. (B) The leaves are large, pinnately compound megaphylls.
Members of the class Lycopsida are characterized by the presence of microphylls, which are small, simple leaves with only a single, unbranched vascular vein. They do not possess large, complex megaphylls like those found in ferns and seed plants. Their sporophyte body is differentiated into true roots, stems, and leaves, and their reproductive structures are often organized into distinct strobili. These anatomical features reflect their status as an ancient and distinct lineage of vascular plants.

222. (A) 1 only
Pteridophytes are evolutionary significant as the first terrestrial plants to possess specialized vascular tissues, namely xylem and phloem. However, unlike bryophytes, the dominant and prominent phase in their life cycle is the diploid sporophyte, not the gametophyte. furthermore, while some pteridophytes like Selaginella are heterosporous, many others are homosporous. Most importantly, none of the pteridophytes produce seeds; they reproduce exclusively via spores, distinguishing them from the more advanced gymnosperms and angiosperms.

223. (C) Haploid (n)
In ferns, the prothallus is the gametophyte generation. It develops directly from a haploid spore through mitotic cell division. Since spores are produced by meiosis in the sporophyte, they contain only one set of chromosomes. consequently, every cell within the prothallus remains haploid. The purpose of this stage is to produce haploid gametes—eggs and sperm—which then fuse during fertilization to restore the diploid number in the next sporophyte generation.

224. (D) Pteridospermales
The Pteridospermales, or seed ferns, are an extinct group of Paleozoic and Mesozoic gymnosperms. They are famous for having large, compound leaves that were morphologically identical to the fronds of true ferns, but unlike ferns, they produced seeds on their foliage. This unique combination of features makes them a critical evolutionary link, demonstrating that the seed habit developed within lineages that still retained the vegetative characteristics of their non-seed-bearing ancestors.

225. (A) Presence of stomata on the capsule in Bryopsida, but not always in Hepaticopsida.
A key anatomical difference between the sporophytes of mosses and liverworts is the presence of specialized structures for gas exchange. In the class Bryopsida, the sporophyte capsule is often more complex and typically possesses stomata on its epidermis to regulate water loss and CO_2 uptake. In many liverworts, particularly the more primitive ones, the sporophyte is simpler and lacks these specialized pores, reflecting a different level of physiological sophistication in the sporophytic generation.

226. (B) Eliminated the need for external water for fertilization.
The evolution of the pollen grain was a crucial adaptation for life in diverse terrestrial environments. In more primitive plants, motile sperm required a film of liquid water to reach the egg. Gymnosperms utilize wind to transport the highly reduced male gametophyte as a pollen grain directly to the ovule. This process of siphonogamy, where a pollen tube delivers the sperm to the egg, allowed plants to reproduce successfully in arid regions where external moisture is scarce.

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227. (C) Being jointed with distinct nodes and internodes.
Stems of the class Sphenopsida, represented by Equisetum, are uniquely characterized by a jointed or articulated appearance. The stem is divided into distinct nodes and internodes, with the internodes often having longitudinal ridges and grooves. At each node, small, scale-like leaves are arranged in a whorl. This specialized architectural plan, often reinforced with silica, is a diagnostic feature that distinguishes the horsetails from all other groups of vascular plants like ferns and club mosses.

228. (D) Morphological and embryological studies of Indian species
Research on gymnosperms in India has traditionally focused on detailed investigations into the morphology, anatomy, and embryology of native species. Scientists have conducted extensive studies on the reproductive cycles and

life histories of diverse gymnosperms, especially those inhabiting the Himalayan mountain range. This foundational work has been essential for establishing accurate taxonomic classifications and understanding the evolutionary relationships of Indian flora within the broader context of global plant diversity and historical paleobotany.

229. (C) Petrifaction
Petrifaction is a specialized type of fossilization that occurs when mineral-rich water permeates the cells and tissues of a dead plant. Through a slow process of molecular replacement, the original organic matter is substituted with minerals like silica or calcium carbonate. This replacement is so detailed that the internal cellular structure and fine anatomical features are perfectly preserved in stone. Petrifactions provide paleobotanists with high-quality evidence for studying the internal organization and evolution of extinct vascular plants.

230. (D) Small, haploid prothallus stage
In the life cycle of the class Pteropsida, commonly known as ferns, there is a clear alternation of generations. The large, prominent, and vascular plant we recognize is the diploid sporophyte. It produces haploid spores through meiosis. These spores kemudian germinate to form a small, independent, and photosynthetic structure called the prothallus. This prothallus is the haploid gametophyte stage, which bears the sex organs and facilitates sexual reproduction before the next sporophytic generation begins.

231. (C) Dependent or semi-dependent on the gametophyte
In bryophytes, the sporophyte generation is a relatively simple structure that is never free-living. It remains physically attached to the dominant, haploid gametophyte throughout its entire existence. The sporophyte depends on the gametophytic tissue for its mechanical support and for the supply of water and minerals absorbed by the gametophore. In many species, it also derives some or all of its organic nutrients from the parent plant, representing a unique parasitic or semi-parasitic relationship.

232. (D) Bryophyta
In the evolutionary history of plants, a major trend is the shift in dominance from the gametophyte to the sporophyte generation. In Pteridophyta, Gymnosperms, and Angiosperms, the main plant body is the diploid sporophyte, which is independent and complex. However, in Bryophyta, the dominant and prominent generation is the haploid gametophyte. The sporophyte in bryophytes is smaller, short-lived, and permanently dependent on the gametophyte, making this group unique among the land plants.

233. (A) Central pith
The evolutionary transition from a protostele to a siphonostele involved a fundamental change in the organization of the central vascular cylinder. While a protostele has a solid core of xylem tissue, a siphonostele is characterized by the presence of a central core of non-vascular, parenchymatous tissue known as a pith. This development allowed for larger stem diameters and provided a storage region, representing a step toward more complex stelar architectures like the dictyostele and eustele.

234. (B) Gnetales
The order Gnetales is highly significant in plant evolution because its members possess true vessels in their secondary xylem. This feature is characteristic of angiosperms and is absent in almost all other gymnosperms, whose xylem consists primarily of tracheids. The presence of vessels, along with other shared traits such as floral-like strobili and a reduced gametophyte, has led researchers to consider Gnetales as an important evolutionary link between gymnosperms and the flowering plants.

235. (C) The sporophyte contains an intercalary meristem.
Members of the class Hepaticopsida, or liverworts, typically have a thalloid or leafy gametophyte and unicellular, unbranched rhizoids. While their capsules often contain elaters to assist in spore dispersal, their sporophytes do not possess an intercalary meristem. The intercalary meristem is a unique feature of the hornworts (Anthocerotopsida), which allows their sporophytes to grow continuously. In liverworts, the growth of the sporophyte is determinate, stopping once the capsule reaches maturity and releases its spores.

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236. (D) It is a prerequisite for the evolution of the seed habit.
Heterospory is an essential milestone in plant evolution because it provided the necessary biological conditions for the development of seeds. By producing two distinct types of spores—microspores and megaspores—plants were able to separate the roles of male and female gametophytes. The subsequent retention and protection of the megaspore and its female gametophyte within the parent megasporangium eventually led to the formation of the ovule and the specialized structure of the modern seed.

237. (A) True roots and leaves
The class Psilopsida includes the most primitive living vascular plants, characterized by an exceptionally simple body plan. Their sporophyte consists of an aerial, dichotomously branched stem and a subterranean rhizome, but it completely lacks true roots and leaves. Absorption is handled by hair-like rhizoids on the rhizome, while photosynthesis occurs primarily in the green stem. This primitive morphology provides important evidence for the early stages of vascular development in the history of land plants.

238. (A) Both Statement I and Statement II are correct.
Gymnosperms possess immense economic value. Their extensive forests are the primary source of softwood timber, high-quality paper pulp, and industrial resins. beyond these uses, certain gymnosperms also provide food. The stem of Cycas contains a large amount of starch that can be processed into "sago," and its seeds are also used as a food source in various cultures. These diverse applications highlight the importance of gymnosperms in both global industries and local economies.

239. (C) Bryophyta
The classification of the division Bryophyta into its three major classes is fundamentally based on the morphology and complexity of the sporophyte generation. Differences in the structure of the capsule, the presence or absence of a seta, and the specialized mechanisms for spore dispersal—such as elaters in liverworts or peristome teeth in mosses—are key diagnostic features. These sporophytic traits, combined with gametophytic characteristics, provide the basis for distinguishing Hepaticopsida, Anthocerotopsida, and Bryopsida.

240. (D) A dominant sporophyte and small independent gametophyte
In the class Lycopsida, which includes genera like Lycopodium, the life cycle is defined by an alternation of generations where the sporophyte is the prominent phase. This diploid generation is a vascular plant with true roots, stems, and leaves. It produces haploid spores that germinate into a much smaller, independent, and free-living gametophyte. This gametophyte bears the sex organs and produces gametes, representing the sexual phase that leads to the formation of a new sporophyte.

241. (A) Their bisporangiate strobili
The extinct order Cycadeoidales, also known as Bennettitales, possessed highly advanced reproductive structures that were strikingly "flower-like." These strobili were often bisporangiate, meaning they contained both pollen-producing and ovule-bearing organs in a single organized structure, often surrounded by protective bracts. This sophisticated arrangement is far more complex than the unisexual cones found in most other gymnosperms and has been extensively studied to understand the possible evolutionary paths leading to the origin of flowering plants.

242. (B) Riccia
Riccia is a representative genus of the class Hepaticopsida within the division Bryophyta. It is characterized by a simple, thalloid gametophytic plant body and a very basic sporophyte consisting only of a capsule. Selaginella and Equisetum are pteridophytes with vascular tissue, while Pinus is a gymnosperm that produces seeds. Identifying Riccia as a bryophyte depends on recognizing its non-vascular nature and the dominance of the haploid gametophyte in its life cycle.

243. (C) Increasing complexity to support larger plant bodies
The evolution of the stele in pteridophytes shows a clear progression from simple to complex organizations. This trend allowed for a more efficient distribution of vascular tissues and improved structural support. By moving from a solid core of xylem to configurations with central

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pith, leaf gaps, and subdivided vascular strands, plants were able to develop larger stems and more numerous, complex leaves. This increased anatomical complexity was essential for the successful radiation of vascular plants into diverse terrestrial habitats.

244. (D) Large, strap-shaped leaves and platyspermic seeds.
The Corditales were an extinct group of Paleozoic gymnosperms characterized by being tall, woody trees. Their vegetative morphology was unique, featuring long, strap-shaped leaves that could reach several meters in length. Their reproductive structures produced seeds that were typically flattened or "platyspermic." As a major group of early woody plants, the Corditales provide important evolutionary evidence for the diversification of seed plants and the development of the coniferous growth form in ancient Earth history.

245. (A) P-3, Q-4, R-1, S-2
Common names for various plant groups reflect their distinctive morphological features. Hepaticopsida are called liverworts due to their lobed, thalloid bodies. Bryopsida are known as mosses, featuring leafy gametophores. Sphenopsida are called horsetails because of their branched, jointed stems. Lycopsida are referred to as club mosses or spike mosses due to their microphylls and cone-like strobili. Correctly matching these common names to their taxonomic classes is essential for effective communication in botanical studies.

246. (B) 2n
The spore mother cell is a specialized cell located within the sporogenous tissue of a bryophyte's sporophyte capsule. Since the sporophyte generation is diploid, these cells also possess the full diploid complement of chromosomes, or 2n. Each spore mother cell kemudian undergoes the process of meiosis to produce four haploid spores. This transition from diploidy to haploidy is a critical step in the life cycle, as it initiates the next gametophytic generation.

247. (C) The fern sporophyte is independent and well-differentiated.
A fundamental distinction between the life histories of ferns and mosses lies in the relationship between their alternating generations. In mosses, the sporophyte is small and remains permanently dependent on the dominant gametophyte. In ferns, however, the sporophyte is the dominant generation. although it starts as a dependent zygote on the prothallus, it rapidly develops into a large, independent, and photosynthetic vascular plant with true roots, stems, and leaves, which forms the main organism.

248. (D) Progressive reduction and dependence of the gametophyte
A major evolutionary trend observed across the gymnosperms is the increasing reduction and structural simplification of the gametophyte generation. Unlike more primitive plants where the gametophyte is independent and prominent, in gymnosperms, both male and female gametophytes are highly reduced. They are never free-living and are instead entirely retained within and dependent upon the sporophyte for protection and nutrition. This extreme reduction is a hallmark of the advanced reproductive strategy of all seed-producing plants.

249. (A) Both A and R are true and R is the correct explanation of A.
In India, the Himalayan mountain range is the primary geographical region for the distribution of diverse gymnosperm species. The cool temperate and sub-alpine climates found at these higher altitudes provide the ideal environmental conditions for the growth of conifers. Significant genera such as Pinus, Cedrus, and Abies form extensive forests across the Himalayas. The combination of suitable temperature, moisture, and elevation makes this region a critical habitat for the country's gymnosperm diversity.

250. (B) A simple protostele
The internal anatomy of the stem in members of the class Psilopsida, such as Psilotum, is characterized by its relative simplicity. It typically possesses a protostele, which is the most primitive type of vascular arrangement. This consists of a solid central core of xylem tissue completely surrounded by a layer of phloem, with no central pith. This primitive stelar configuration is consistent with their overall simple body plan and their evolutionary position as early vascular plants.

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251. (C) Wood is generally non-porous and composed of tracheids.
Gymnosperm anatomy is distinguished by its homoxylous nature, meaning the xylem consists primarily of tracheids and typically lacks true vessels. This results in "non-porous" wood that is structurally uniform. Their phloem also lacks companion cells, having albuminous cells instead. Gymnosperms exhibit significant secondary growth due to the activity of a vascular cambium, producing hard, compact wood. These features are characteristic of their evolutionary stage, lying between the simpler vascular cryptogams and the more advanced flowering plants.

252. (C) 2 and 3 only
Bryophytes are economically and ecologically valuable for several reasons. Sphagnum moss is extensively used as a packing material because of its remarkable water-holding capacity. ecologically, bryophytes are vital pioneer species that colonize bare rock and soil, initiating the process of succession. However, they are not used for timber because they are small, non-vascular plants that do not produce secondary wood. Their contributions are instead focused on soil stabilization, moisture retention, and early ecosystem development.

253. (C) Sporangia
In ferns, the diploid sporophyte produces haploid spores through the process of meiosis. This specialized cell division occurs within reproductive structures called sporangia. These sporangia are often organized into clusters known as sori, which are commonly found on the lower surface of mature fronds. Once the spores are formed and have reached maturity, the sporangia open through a mechanical process of dehiscence to release the spores into the environment for dispersal and colonization.

254. (D) Small, independent gametophyte.
The life history of the Sphenopsida, represented by horsetails like Equisetum, follows the typical pattern of an alternation of generations. The prominent generation is the diploid sporophyte with its characteristic jointed stem. it produces spores that germinate into a small, heart-shaped, and photosynthetic gametophyte known as a prothallus. This gametophyte is free-living and independent of the sporophyte, functioning solely to produce gametes and provide the site for fertilization, thus continuing the reproductive cycle.

255. (A) Coniferales
The presence of resin canals is a distinctive anatomical feature of the order Coniferales, particularly within the family Pinaceae. These specialized channels are found in the wood, bark, and leaves (needles) of trees like Pinus. They secrete resins that serve as a defense mechanism against insects and fungal pathogens and help the plant seal wounds. These resins are of significant industrial value, providing the raw material for the production of turpentine, varnishes, and other valuable chemical products.

256. (B) Pteropsida
The division Bryophyta is classified into three distinct classes: Hepaticopsida (liverworts), Anthocerotopsida (hornworts), and Bryopsida (mosses). Pteropsida is not a class of bryophytes; it is a major class within the division Pteridophyta that includes the true ferns. Pteropsids are vascular plants with a dominant sporophyte generation and megaphyllous leaves, making them fundamentally different from the non-vascular bryophytes whose life cycle is dominated by the haploid gametophytic phase.

257. (A) R, Q, S, P
The classes of pteridophytes reflect a general evolutionary trend from simple to complex organization. Psilopsida is considered the most primitive group, lacking true roots and leaves. Lycopsida follows, possessing simple microphyllous leaves. Sphenopsida exhibits more specialized jointed stems and strobili. finally, Pteropsida (the true ferns) is regarded as the most advanced, featuring large, complex megaphylls and sophisticated vascular architectures. This progression illustrates the increasing structural and functional complexity within the vascular cryptogams.

258. (B) The retention of the megaspore within the megasporangium (ovule).
The development of the seed habit was a complex evolutionary transition that required two fundamental changes. first, the emergence of heterospory provided the specialized male and female lineages. Second, and most

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crucially, the megaspore had to be retained and germinate within the megasporangium of the parent sporophyte instead of being released. This protection, combined with the evolution of integuments to form an ovule, ensured the embryo's survival in terrestrial habitats and eliminated the need for free water during fertilization.

259. (C) A protostele or a siphonostele.
The vascular anatomy of the stem in Lycopsida is generally characterized by relatively simple stelar types. In many members, a protostele is present, consisting of a solid central core of xylem surrounded by phloem. in more advanced species, this may develop into a siphonostele, which includes a central pith. These stelar configurations do not exhibit the leaf gaps associated with megaphylls, reflecting the simpler microphyllous leaves that are characteristic of this ancient vascular plant lineage.

260. (D) Plant morphology, anatomy, and paleobotany research
Professors P.N. Mehra and Birbal Sahni were iconic figures in Indian botany who made monumental contributions to several fields. Mehra's work focused extensively on the morphology and cytology of living gymnosperms and ferns. Sahni was a world-renowned paleobotanist whose research into fossil plants revolutionized our understanding of ancient Earth history and evolutionary lineages. Together, their legacy includes a wealth of knowledge regarding the anatomy, reproduction, and evolutionary development of diverse plant groups across the Indian subcontinent.

261. (A) Prothallus
In the life cycle of the class Pteropsida, which includes the true ferns, the haploid gametophyte is a small, heart-shaped, and photosynthetic structure known as the prothallus. It grows independently on moist soil and produces the male and female gametes in antheridia and archegonia. This stage is relatively short-lived compared to the dominant sporophyte but is essential for the sexual reproduction process, providing the necessary environment for fertilization to occur and for the new sporophyte to begin its development.

262. (B) Presence of motile antherozoids requiring water for fertilization
A primitive trait shared by both bryophytes and pteridophytes is their dependence on external liquid water for sexual reproduction. In both groups, the male gametes, known as antherozoids, are flagellated and motile. To reach the egg cell within the archegonium, these sperm must swim through a film of moisture on the surface of the plant. This requirement for water remains a significant limiting factor in the distribution and reproduction of these "cryptogamic" groups in terrestrial environments.

263. (C) Nature of the stele, leaf type, and sporangia
The classification of the division Pteridophyta into its four major classes is based on fundamental differences in their vegetative and reproductive morphology. Psilopsida, Lycopsida, Sphenopsida, and Pteropsida are distinguished by the presence or absence of true roots and leaves, the type of leaves (microphylls or megaphylls), the organization of the vascular stele, and the location and structure of their sporangia. These key anatomical features reflect the major evolutionary divergent paths taken by different lineages of vascular cryptogams.

264. (C) Statement I is correct but Statement II is incorrect.
In gymnosperms, the female gametophyte is a multicellular tissue that develops from a haploid megaspore within the ovule. This tissue serves as the source of nutrition for the developing embryo. Importantly, this endosperm is a haploid (n) tissue that forms before fertilization. This is a key difference from angiosperms, where the endosperm is a triploid (3n) tissue that develops only after the process of double fertilization, representing a distinct evolutionary advancement in flowering plants.

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265. (A) The role of Azolla in nitrogen fixation.
Beyond their use as ornamental plants, certain pteridophytes have substantial economic and agricultural importance. Azolla, a small aquatic fern, houses symbiotic cyanobacteria that are highly efficient at fixing atmospheric nitrogen. In many parts of Asia, Azolla is traditionally grown in rice paddies as a natural biofertilizer. By enriching the water and soil with nitrogen, it significantly enhances rice yields and reduces

the reliance on expensive chemical fertilizers, demonstrating a sustainable practice based on plant biology.

266. (B) Xylem vessels and a form of double fertilization
The order Gnetales includes the most advanced gymnosperms, exhibiting several features that are strikingly similar to those of angiosperms. Most significantly, their secondary xylem contains true vessels, whereas other gymnosperms possess only tracheids. some members of this group also show a reproductive process analogous to double fertilization and have floral-like strobili. These advanced traits suggest that Gnetales represent an evolutionary transition or share a common ancestry with the flowering plants, making them a subject of intense scientific interest.

267. (C) Haploid (n)
In the life cycle of bryophytes, the dominant and prominent generation is the gametophyte. This phase is haploid, meaning each cell contains only a single set of chromosomes. The gametophyte is the independent and photosynthetic stage responsible for the production of gametes through mitosis. The diploid sporophyte, which results from the fusion of these gametes, remains attached to and nutritionally dependent on the haploid gametophytic plant body throughout its entire existence.

268. (D) Large megaphylls with leaf gaps
The development of a dictyostele is an evolutionary consequence of the emergence of large, complex leaves known as megaphylls. Because megaphylls require substantial vascular traces that branch off from the stem's vascular cylinder, they leave behind significant interruptions known as leaf gaps. In plants where leaves are numerous and large, these gaps overlap, causing the central vascular cylinder to appear as a network of separate strands or meristeles, creating the characteristic architecture of a dictyostele.

269. (A) Fast-growing, deciduous trees with needle-like leaves.
Members of the order Cycadales are characterized by a slow growth rate and an evergreen, palm-like habit. They possess large, pinnately compound leaves rather than needle-like ones. Cycads are dioecious plants that produce large male and female cones on separate individuals and retain primitive traits such as motile male gametes. Needle-like leaves and fast-growing deciduous habits are more typical of certain members of the Coniferales or Ginkgoales, respectively, highlighting the distinct morphology of the cycad lineage.

270. (B) The structure of the sporophyte and nature of the rhizoids.
The classification of bryophytes into Hepaticopsida, Anthocerotopsida, and Bryopsida is primarily based on fundamental anatomical and developmental differences. Liverworts and hornworts typically possess unicellular rhizoids, while mosses have multicellular ones. furthermore, the structure and complexity of the sporophyte vary significantly across these classes, ranging from the simple capsules of some liverworts to the complex, horn-like sporophytes of hornworts and the specialized capsules with peristome teeth found in mosses.

271. (C) A subterranean and saprophytic structure
In the class Psilopsida, the life cycle involves a prominent aerial sporophyte and a very small, inconspicuous gametophyte. This gametophyte is typically subterranean, meaning it grows underground and lacks chlorophyll. consequently, it cannot perform photosynthesis and must obtain its nutrition saprophytically, usually through a symbiotic association with mycorrhizal fungi. This type of gametophyte development is common among several primitive vascular plant lineages and contrasts with the green, photosynthetic surface prothalli seen in most modern ferns.

272. (D) Increasing independence from water for fertilization
A major evolutionary milestone in the transition from pteridophytes to gymnosperms is the development of siphonogamy. Pteridophytes require external water for their motile sperm to swim to the egg. In contrast, gymnosperms produce pollen grains that are dispersed by wind. these grains grow a pollen tube to deliver the sperm directly to the ovule. This adaptation eliminated the need for liquid moisture during the fertilization process, allowing seed plants to successfully inhabit and reproduce in a wide range of dry terrestrial environments.

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273. (A) A dichotomously branched, dorsiventral thallus with scales and rhizoids on the ventral surface.
The liverwort Marchantia possesses a characteristic thalloid body plan that is dorsiventrally flattened and exhibits regular dichotomous branching. Its upper or dorsal surface often shows a midrib and specialized gemma cups. the lower or ventral surface is equipped with several rows of multicellular scales and unicellular rhizoids, which function for protection, anchorage, and absorption. This specific morphological organization is a diagnostic feature of the class Hepaticopsida and reflects its adaptation to growth on moist, flat surfaces.

274. (B) Selaginella
Selaginella is an evolutionary significant pteridophyte because it exhibits heterospory, the production of two distinct types of spores. This condition is a crucial prerequisite for the development of the seed habit. in some species of Selaginella, the megaspore is retained within the megasporangium for a period, where it begins to germinate and form the female gametophyte. This specialized reproductive strategy represents an early and important stage in the evolutionary transition from spore-bearing plants to those that produce seeds.

275. (B) P-3, Q-2, R-1, S-4
Major plant groups are distinguished by their dominant life cycle phases and key morphological traits. Bryophyta are characterized by a dominant gametophyte generation. Pteridophyta are known as vascular cryptogams because they possess vascular tissue but reproduce via spores. Coniferales are gymnosperms that produce naked seeds in organized cones. Cycadales feature a distinct palm-like habit with large, compound leaves. Understanding these core features is fundamental to the study of plant diversity and evolutionary history across the terrestrial landscape.

276. (D) Leafy gametophores with multicellular rhizoids
Members of the class Bryopsida, commonly known as mosses, are characterized by a relatively complex gametophytic body. After a juvenile protonema stage, they develop an erect axis with spirally arranged leaf-like structures, known as the leafy gametophore. Another diagnostic feature is the presence of multicellular, branched rhizoids that often have oblique septa. This structural organization is more advanced than the simple thalloid bodies and unicellular rhizoids typical of liverworts and hornworts, distinguishing mosses within the division Bryophyta.

277. (A) A dominant sporophyte and a reduced independent gametophyte
The life history of the Sphenopsida, represented by Equisetum, follows the typical pattern of an alternation of generations found in vascular cryptogams. The diploid sporophyte is the prominent, long-lived generation characterized by its jointed stems. It produces haploid spores through meiosis, which germinate into a small, independent, heart-shaped gametophyte or prothallus. This gametophyte is photosynthetic and bears the sex organs, facilitating sexual reproduction before a new sporophyte begins to develop, thereby completing the reproductive cycle of the plant.

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278. (B) Timber and pulpwood
Coniferous gymnosperms such as Pinus, Cedrus, and Picea are of immense global economic importance. They are the primary source of softwood, which is extensively utilized in the construction and furniture industries due to its strength and ease of processing. Furthermore, their long fibers are highly valued for the manufacture of high-quality paper pulp and cardboard products. These trees form vast forests that are managed worldwide as a sustainable source of these essential raw materials for various human industrial applications.

279. (A) Both A and R are true and R is the correct explanation of A.
The fossil record provides only an incomplete picture of ancient life because the process of fossilization is an extremely rare event. For an organism to be preserved, it must be buried quickly in an environment that prevents decomposition by bacteria or consumption by scavengers. Most living things die and decay completely without leaving any trace. consequently, only a tiny fraction of past biological diversity has been captured in the geological strata, leaving

many gaps in our understanding of evolutionary history.

280. (C) Dictyostele or siphonostele
The rhizome of most modern ferns, belonging to the class Pteropsida, typically exhibits advanced stelar architectures. Common types include the siphonostele, where vascular tissue surrounds a central pith, or more frequently the dictyostele. A dictyostele is formed when the vascular cylinder is interrupted by numerous overlapping leaf gaps caused by the departure of vascular traces to the large fronds. This resulting network of separate vascular strands, or meristeles, represents a structural adaptation to support the complex megaphyllous foliage.

281. (D) It possesses an intercalary meristem for prolonged growth.
A unique and defining feature of the sporophyte in the class Anthocerotopsida, or hornworts, is the presence of an intercalary meristem located at the base of the capsule. This specialized zone of actively dividing cells allows the sporophyte to grow continuously throughout its life. As a result, the mature spores are released from the tip while new tissue is simultaneously produced at the base. this continuous growth mechanism is not found in mosses or liverworts and distinguishes the horn-like sporophyte of this class.

282. (B) 1 and 2 only
Pteridophytes represent a major evolutionary step as the first terrestrial plants to possess specialized vascular tissues, namely xylem and phloem. In their life cycle, the dominant and prominent phase is the diploid sporophyte, which is differentiated into true roots, stems, and leaves. However, pteridophytes do not produce seeds; they reproduce exclusively via spores. The production of seeds is a more advanced characteristic that only evolved later in the lineages leading to gymnosperms and angiosperms, distinguishing them from vascular cryptogams.

283. (C) Cool, moist, and shady areas
Although bryophytes have adapted to life on land, their physiology and reproductive strategies heavily restrict them to environments with consistent moisture. Because they lack a sophisticated vascular system and a thick, protective cuticle, they are highly susceptible to drying out. Furthermore, they require an external film of water to facilitate the movement of their motile male gametes for fertilization. consequently, they are most common and diverse in habitats such as forest floors, riverbanks, and shaded crevices where cool and damp conditions prevail.

284. (D) The gametophytes are highly reduced and dependent on the sporophyte.
A key difference between gymnosperms and pteridophytes lies in the degree of gametophyte development. In pteridophytes, the gametophyte is usually a small but independent and free-living prothallus. In gymnosperms, however, the gametophytic generation is extremely reduced and never becomes independent. Both male and female gametophytes remain entirely enclosed within the tissues of the sporophyte, such as in pollen grains and ovules. This high degree of reduction and dependence is a hallmark of the advanced reproductive strategy seen in all seed-producing plants.

285. (A) Dry or arid regions
Members of the gymnosperm order Ephedrales, particularly those in the genus Ephedra, are highly specialized for life in dry or arid environments. They are typically found in deserts, rocky slopes, and sand dunes. These plants exhibit several xerophytic adaptations, such as green, photosynthetic stems and highly reduced, scale-like leaves that minimize water loss through transpiration. This ability to thrive in harsh, water-scarce conditions highlights the diverse ecological specializations found within the gymnosperms and their successful colonization of varied terrestrial habitats.

286. (B) Multicellular and have a sterile jacket layer
Sexual reproduction in bryophytes involves specialized multicellular sex organs. The male antheridia produce motile antherozoids, while the female archegonia produce a single egg. A characteristic feature of these organs is the presence of an outer layer of sterile cells known as a jacket. This jacket layer provides essential protection to the developing gametes from mechanical damage and desiccation in the terrestrial environment. This multicellular, jacketed organization is a significant evolutionary

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advancement over the simpler, often unicellular reproductive structures found in most algae.

287. (C) Megaspore retention within the megasporangium (ovule)
The evolution of the seed habit was a multi-stage process, but the final and most crucial step was the permanent retention of the megaspore within the megasporangium. In earlier plants, spores were released into the environment. in the lineage leading to seed plants, the megaspore remained and germinated inside the parent tissue to form the female gametophyte. This transition, combined with the development of protective integuments, created the ovule and ensured the protection and nourishment of the embryo, representing the definitive arrival of the seed habit.

288. (B) Leaves are large megaphylls, often called fronds
The class Pteropsida is the largest group of pteridophytes and is characterized by the presence of large, complex leaves known as megaphylls or fronds. Unlike the simple microphylls found in lycophytes, these fronds have a highly branched network of vascular veins and are associated with distinct leaf gaps in the stem's vascular cylinder. These leaves serve as the primary site for photosynthesis and also bear the reproductive sporangia, illustrating the high degree of morphological and functional complexity that defines the true ferns.

289. (A) As a primary source of staple grains like rice and wheat
Gymnosperms have immense economic value as sources of high-quality softwood timber, resins, turpentine, and various essential oils used in industry. Some species also provide edible seeds, such as the chilgoza pine. however, they are not the source of staple grains like rice, wheat, or corn. These essential food crops are members of the angiosperms, specifically the grass family. Gymnosperms lack the specialized floral and fruit structures necessary for the production of true grains, distinguishing their economic utility from that of flowering plants.

290. (B) Pteridospermales
The Pteridospermales, commonly known as seed ferns, are an entirely extinct group of Paleozoic and Mesozoic gymnosperms. They are of great evolutionary significance because they possessed vegetative foliage that was morphologically identical to true ferns but reproduced through the formation of true seeds. While other orders such as Coniferales, Cycadales, and Gnetales still have living representatives today, the Pteridospermales are known only through the fossil record, providing a critical link in our understanding of how the seed habit first emerged in land plants.

291. (C) The gametophyte and sporophyte are morphologically distinct
The alternation of generations in bryophytes is termed heteromorphic because the two phases of the life cycle—the haploid gametophyte and the diploid sporophyte—differ significantly in their size, structure, and appearance. The gametophyte is the prominent, independent, and photosynthetic phase, while the sporophyte is a much smaller, relatively simple structure that remains permanently attached to the gametophore. This contrast between the two generations is a fundamental characteristic of bryophytes, distinguishing them from organisms with isomorphic alternation where both phases appear similar.

292. (D) Xylem, phloem, and pericycle
In pteridophytes, the stele is the central vascular cylinder of the stem and root. It comprises all the tissues located internal to the endodermis, which include the primary xylem, primary phloem, and the pericycle. In some more advanced stelar organizations, a central core of parenchyma called a pith may also be present. The organization and evolution of these tissues—ranging from solid protosteles to complex dictyosteles—are key features used in the anatomical study and taxonomic classification of vascular plants.

293. (C) The evolution of the seed for reproduction and dispersal
A pivotal evolutionary advancement of gymnosperms over more primitive plant groups is the development of the seed. Unlike bryophytes and pteridophytes that reproduce via spores, gymnosperms produce seeds that contain a protected embryo and a nutrient supply. This innovation allowed for much greater reproductive success and dispersal in diverse terrestrial habitats, as the seed can remain

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dormant until environmental conditions are favorable. This, along with the development of pollen tubes, enabled gymnosperms to colonize drier regions effectively and dominate many ancient ecosystems.

294. (D) Protostele
The internal anatomy of the class Psilopsida, which includes some of the most primitive vascular plants, is characterized by a protostele. This stelar type consists of a solid central core of xylem tissue completely surrounded by a layer of phloem, with no central pith. This simple vascular organization is consistent across both the aerial stems and the subterranean rhizomes of the plant. The presence of a protostele highlights the primitive evolutionary status of these plants, representing one of the earliest stages in the development of vascular systems.

295. (D) Absence of archegonia in some members
The order Gnetales includes the most advanced gymnosperms, exhibiting several traits that resemble those of angiosperms. A unique feature found in certain members, such as Gnetum and Welwitschia, is the complete absence of organized archegonia during the development of the female gametophyte. Instead, the eggs are produced in a less structured manner. This reduction of the gametophyte generation, combined with the presence of xylem vessels and floral-like reproductive structures, underscores the specialized evolutionary position of the Gnetales within the gymnosperm lineage.

296. (D) Gametophyte
In the life cycle of bryophytes, the dominant and prominent generation is the haploid gametophyte. This phase is the long-lived, independent, and photosynthetic plant body that we commonly recognize. It is responsible for the production of gametes through sexual reproduction. The diploid sporophyte, in contrast, is smaller and remains permanently attached to the gametophyte, deriving its mechanical support and nutrition from it. This dominance of the gametophytic phase is a defining feature that distinguishes bryophytes from all groups of vascular plants where the sporophyte is dominant.

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297. (A) Heterosporous Pteridophytes
The origin of the seed habit is best understood by studying certain groups of heterosporous pteridophytes, both living and extinct. These plants produce two distinct types of spores: microspores and megaspores. The evolutionary transition involved the retention of the megaspore within the megasporangium of the parent sporophyte. Genera like Selaginella demonstrate an early stage of this development, illustrating how the specialization of spores and the internal protection of the female gametophyte provided the biological framework for the eventual evolution of the seed habit.

298. (B) Small and simple (microphylls)
Members of the class Lycopsida are characterized by a sporophyte that produces microphylls. These are small, simple leaves that possess only a single, unbranched vascular vein or trace. Unlike the large, complex megaphylls found in ferns and seed plants, microphylls do not create leaf gaps in the vascular cylinder of the stem. This leaf type is a diagnostic feature of the lycophytes, representing an ancient and distinct evolutionary lineage of vascular plants that has maintained this simple vegetative morphology for millions of years.

299. (C) Pinus gerardiana (Chilgoza pine)
Gymnosperms provide several nutritious food products, with one of the most significant being the edible seeds obtained from the chilgoza pine, Pinus gerardiana. These seeds, commonly known as chilgoza or pine nuts, are harvested from mature cones and are highly valued for their rich oil content and pleasant flavor. They are an important commercial crop in the mountainous regions of northern India and neighboring areas. This example illustrates that while gymnosperms are primarily known for timber, they also contribute valuable non-timber forest products to human diets.

300. (D) Dominant sporophyte and small independent gametophyte
The life cycle of the class Pteropsida, which includes the true ferns, is characterized by an alternation of generations between two morphologically distinct phases. The prominent, long-lived, and vascular plant we observe is the diploid sporophyte. it produces haploid spores

that germinate into a much smaller, independent, and photosynthetic gametophyte known as the prothallus. While the gametophyte is free-living, it is relatively short-lived compared to the sporophyte, which represents the main body of the plant adapted for successful survival and dispersal in various terrestrial environments.

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CHAPTER 03

Morphology and Taxonomy of Angiosperms

1. Which of the following best defines placentation in angiosperms?
(A) The fusion of petals to form a corolla tube.
(B) The arrangement of ovules within the ovary.
(C) The arrangement of sepals in a whorl.
(D) The process of pollen transfer to the stigma.

2. What is the primary purpose of the International Code of Botanical Nomenclature (ICBN/ICN)?
(A) To provide a stable and universal system for naming taxonomic groups of plants.
(B) To develop a classification system based on the evolutionary history of plants.
(C) To provide guidelines for the cultivation and conservation of rare plants.
(D) To publish and maintain an official list of all known plant species worldwide.

3. Which of the following statements correctly describes a characteristic of the family Ranunculaceae?
(A) The inflorescence is consistently a capitulum containing numerous sessile florets.
(B) The fruit is exclusively a siliqua characterized by a persistent central replum.
(C) The gynoecium is typically apocarpous with numerous carpels on an elongated receptacle.
(D) The stamens are always united into a single bundle to form a distinct staminal tube.

4. Consider the following statements about floral induction.
Statement I: Floral induction is the physiological process where a vegetative apical meristem transitions to producing flowers.
Statement II: This process is entirely controlled by the plant's genetic makeup and is independent of external environmental cues.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

5. Match List I with List II.
List I: (Placentation Type)
P. Parietal,
Q. Axile,
R. Basal,
S. Marginal
List II: (Example Family)
1. Asteraceae,
2. Solanaceae,
3. Brassicaceae,
4. Fabaceae
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

6. Which of the following is NOT considered a primary taxonomic tool for research and identification?
(A) Herbarium
(B) Nursery for commercial plant propagation
(C) Botanical Garden
(D) Flora (taxonomic literature)

7. A flower is described in semi-technical language as actinomorphic, hypogynous, with five free sepals, five free petals, numerous stamens, and a superior, multicarpellary, apocarpous ovary. To which family does it most likely belong?
(A) Lamiaceae
(B) Poaceae
(C) Asteraceae
(D) Ranunculaceae

8. Consider the following Assertion and Reason.
Assertion (A): The APG IV system of classification is widely regarded as a phylogenetic system.

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Reason (R): It is constructed primarily using molecular data, such as DNA sequences, to infer evolutionary relationships among plant taxa.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(A) A is true but R is false.
(D) A is false but R is true.

9. Which statement regarding the origin and evolution of angiosperms is generally considered incorrect?
(A) Angiosperms appeared and diversified with remarkable speed during the Cretaceous period.
(B) The evolution of the flower and co-evolution with insect pollinators were key factors.
(C) The fossil record shows a clear and gradual transition from gymnosperms to angiosperms.
(D) Primitive angiosperms are believed to have had simple, leaf-like stamens and carpels.

10. The biological species concept, proposed by Ernst Mayr, most appropriately defines a species as:
(A) Interbreeding natural populations reproductively isolated from other such groups.
(B) A group of individuals that appear morphologically identical in all visible traits.
(C) The smallest diagnosable cluster of organisms with a shared pattern of ancestry.
(D) A lineage evolving separately from others with its own evolutionary tendencies.

11. Consider the following statements about the family Brassicaceae:
1. The fruit is a specialized capsule known as a siliqua or silicula.
2. The corolla is cruciform, consisting of four petals arranged in the form of a cross.
3. The stamens are typically tetradynamous, with four long and two short filaments.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

12. In biogeography and taxonomy, the term endemism refers to a species that is:
(A) Found in a dormant state for a major part of its life cycle.
(B) Confined to a specific and defined geographical area and found nowhere else.
(C) Ecologically dominant in its habitat.
(D) Artificially introduced into a new region by human activity.

13. Identify the correct pair of a plant family and its well-known economically important member.
(A) Lamiaceae - Chickpea
(B) Poaceae - Sunflower
(C) Solanaceae - Tomato
(D) Fabaceae - Basil

14. Arrange the following taxonomic ranks in the correct descending hierarchical order (from highest to lowest).
1. Family
2. Order
3. Class
4. Genus

(A) 3, 2, 1, 4
(B) 2, 3, 1, 4
(C) 3, 1, 2, 4
(D) 4, 1, 2, 3

15. Cause: The shoot apical meristem receives inductive signals. Effect: The meristem transitions from vegetative growth to reproductive growth, initiating floral development. Which of the following is true?
(A) The effect is a direct consequence of the cause.
(B) The cause is a direct result of the effect.
(C) The effect directly leads to the cause.
(D) The cause and effect are unrelated phenomena.

16. Consider the following statements.
Statement I: A herbarium is a 'dry garden' consisting of pressed and dried plant specimens.
Statement II: The primary and most crucial function of a herbarium is the ex-situ conservation of living endangered plant species.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.

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(D) Statement I is false but Statement II is true.

17. Identify the incorrect pair regarding a characteristic morphological feature and its associated family.
(A) Gynobasic style - Lamiaceae
(B) Monadelphous stamens - Poaceae
(C) Syngenesious stamens - Asteraceae
(D) Tetradynamous stamens - Brassicaceae

18. Match List I with List II.
List I: (Taxonomic Technique)
P. Palynology,
Q. Cytotaxonomy,
R. Serotaxonomy,
S. Chemotaxonomy
List II: (Basis of Study)
1. Chromosomes,
2. Pollen morphology,
3. Secondary metabolites,
4. Antigen-antibody reactions
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

19. The family Papaveraceae is characterized by the presence of latex. From which species is the economically important product opium extracted?
(A) Argemone mexicana
(B) Chelidonium majus
(C) Papaver somniferum
(D) Fumaria indica

20. A taxonomist using a dichotomous key to identify a specimen finds petals. Following the lead 1a. Flowers with petals, the taxonomist should:
(A) Immediately conclude the entire identification process for the species.
(B) Re-read the entire key from the beginning to ensure no mistakes occurred.
(C) Discard the key as it is far too simple for a professional identification.
(D) Follow the instructions or go to the couplet number indicated at the end.

21. Consider the following Assertion and Reason.
Assertion (A): The characteristic fruit of the family Fabaceae is a legume.
Reason (R): A legume develops from a monocarpellary, superior ovary and typically dehisces along both the dorsal and ventral sutures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

22. Which statement correctly describes a key reproductive feature of the family Malvaceae?
(A) The gynoecium is always apocarpous with a single carpel.
(B) The presence of a staminal tube formed by the fusion of numerous stamen filaments.
(C) The fruit is a caryopsis with a persistent pericarp.
(D) The flowers are strictly unisexual and epigynous.

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23. Natural systems of classification, such as that of Bentham and Hooker, are based on all the following general principles EXCEPT:
(A) Using a multitude of morphological characters for grouping.
(B) Creating groups based on overall natural affinities and resemblances.
(C) Giving high importance to reproductive structures for classification.
(D) Arranging taxa to reflect their true evolutionary lineage and phylogeny.

24. Consider the following statements regarding phylogenetic systems of classification:
1. Their primary goal is to reflect the evolutionary history and relationships of organisms.
2. Fossil evidence, where available, is considered important for constructing phylogenies.
3. The system of Engler and Prantl is considered an early attempt at a phylogenetic arrangement.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

25. In angiosperm morphology, a carpel is structurally and evolutionarily considered to be a:
(A) Swollen receptacle that encloses the stamens.
(B) Sterile floral appendage that attracts pollinators.
(C) Modified megasporophyll, i.e., a leaf-like structure that bears ovules.
(D) Fused unit of a stamen and a petal.

26. The presence of a cup-shaped structure called a hypanthium, formed from the fusion of the bases of sepals, petals, and stamens, is a characteristic feature of many members of which family?
(A) Rosaceae
(B) Brassicaceae
(C) Fabaceae
(D) Lamiaceae

27. A botanist discovers a new species and publishes its name on a personal blog. According to the ICN, why is this name not validly published?
(A) The plant species was not determined to be of significant economic utility.
(B) The description was not written in classical Greek or formal Latin prose.
(C) The botanist failed to provide a common vernacular name for the species.
(D) It was not published in a recognized scientific journal or qualifying medium.

28. Match List I with List II.
List I: (Family)
P. Apiaceae,
Q. Asteraceae,
R. Lamiaceae,
S. Poaceae
List II: (Characteristic Inflorescence)
1. Capitulum,
2. Spikelet,
3. Umbel,
4. Verticillaster
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-2, S-3

29. Which of the following is an incorrect statement about the family Cucurbitaceae?
(A) Plants are typically climbing or trailing herbs with tendrils.
(B) Flowers are characteristically unisexual and epigynous.
(C) The ovary is superior, syncarpous, and unilocular.
(D) Placentation is parietal, and the fruit is often a pepo.

30. Consider the following statements about molecular taxonomy.
Statement I: Molecular taxonomy utilizes heritable variations in DNA and protein sequences to infer relationships between taxa.
Statement II: It has proven to be a powerful tool that complements, rather than completely replaces, traditional morphology-based taxonomy.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

31. From an evolutionary perspective, what is considered the most primitive or ancestral form of a stamen?
(A) A broad, three-veined, leaf-like structure with microsporangia on its surface.
(B) A well-differentiated structure with a slender filament and a distinct anther.
(C) A minute, scale-like structure lacking a filament, fused to the corolla.
(D) A structure fused with the pistil to form a column.

32. Arrange the following events in the evolutionary history of angiosperms in the most plausible chronological sequence.
1. Radiation
2. Gymnosperm origin
3. Co-evolution
4. Early Cretaceous fossil
(A) 2, 4, 1, 3
(B) 4, 2, 3, 1
(C) 2, 1, 4, 3
(D) 1, 2, 3, 4

33. Consider the following Assertion and Reason.
Assertion (A): The capitulum inflorescence of Asteraceae functions as a single pollination unit, mimicking a large, single flower.

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Reason (R): This aggregation of many small florets into a head is a highly successful strategy for attracting pollinators.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

34. In the context of taxonomic literature, a Flora is best defined as:
(A) A work containing an account of the plants of a region with identification keys.
(B) A collection of living plants maintained for study, conservation, and education.
(C) A specialized dictionary that defines all standard botanical and technical terms.
(D) A treatise on the evolutionary history of the entire global plant kingdom.

35. Members of the family Rubiaceae are characterized by all the following features EXCEPT:
(A) Opposite or whorled simple leaves.
(B) The presence of interpetiolar or intrapetiolar stipules.
(C) An apocarpous gynoecium with numerous free carpels.
(D) An inferior, syncarpous ovary.

36. Consider the following diagnostic features for the family Apocynaceae:
1. Presence of milky or colored latex in vegetative parts.
2. Corolla lobes showing twisted (contorted) aestivation in the bud.
3. Gynoecium consisting of two carpels, often free at the ovary but united by their styles.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

37. In the family Poaceae (Gramineae), the fruit is a caryopsis, which is a:
(A) Fleshy fruit with a hard, stony endocarp.
(B) Dry, dehiscent fruit that splits along two sutures.
(C) Single-seeded, dry, indehiscent fruit where the pericarp is fused with the seed coat.
(D) Winged fruit adapted for wind dispersal.

38. Which of the following is a correct statement regarding the general characteristics of the order Ranales?
(A) It is characterized by a gamopetalous corolla and an inferior ovary.
(B) Members typically have numerous, spirally arranged stamens and an apocarpous gynoecium.
(C) All members of the order are parasitic plants.
(D) The inflorescence is always a cyathium.

39. From an evolutionary standpoint, which type of placentation is generally considered to be the most primitive?
(A) Free-central
(B) Basal
(C) Axile
(D) Laminar or marginal

40. Match List I with List II.
List I: (Family)
P. Rutaceae,
Q. Malvaceae,
R. Brassicaceae,
S. Apiaceae
List II: (Economic Plant)
1. Mustard,
2. Fennel,
3. Sweet Orange,
4. Cotton
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

41. Which statement about the family Solanaceae is incorrect?
(A) The calyx is often persistent and sometimes enlargement occurs.
(B) The ovary is superior, bicarpellary, and characteristically obliquely placed.
(C) Placentation is parietal with a false septum called a replum.
(D) The fruit is typically a berry or a capsule.

42. Consider the following statements.
Statement I: Geographic Information Systems

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(GIS) are tools used in taxonomy to analyze distributions and identify conservation areas.
Statement II: GIS is a laboratory-based biochemical technique for analyzing secondary metabolites in plants.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

43. What is the most significant role of a modern, scientifically-managed botanical garden?
(A) Serving as a beautifully landscaped park for public recreation and leisure activities.
(B) Providing a continuous supply of fresh flowers and ornamental plants to the market.
(C) Acting as a repository for dried and pressed plant specimens for herbarium study.
(D) Functioning as a major center for the ex-situ conservation of plant diversity.

44. Consider the following Assertion and Reason.
Assertion (A): Many members of the Lamiaceae (mint family) are aromatic.
Reason (R): They possess epidermal glandular hairs that secrete volatile essential oils responsible for the aroma.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

45. The group Amentiferae is an artificial assemblage of families traditionally grouped together based on the presence of what characteristic inflorescence?
(A) A capitulum
(B) A cyathium
(C) An ament or catkin
(D) A verticillaster

46. In the family Orchidaceae, the pollen grains are aggregated into waxy masses which are transferred as a single unit during pollination. These masses are known as:
(A) Lodicules
(B) Carpels
(C) Spathes
(D) Pollinia

47. Identify the correct pair matching the characteristic fruit type with its family.
(A) Siliqua - Brassicaceae
(B) Pepo - Solanaceae
(C) Legume - Rosaceae
(D) Caryopsis - Liliaceae

48. Consider the following statements about the family Euphorbiaceae:
1. Many species are characterized by the presence of milky latex.
2. The inflorescence is often a highly specialized pseudanthium called a cyathium.
3. The ovary is consistently inferior, unilocular, and with a single ovule.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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49. The family Asclepiadaceae is known for all the following specialized floral features EXCEPT:
(A) Presence of pollinia.
(B) Numerous, free stamens with versatile anthers.
(C) A complex translator apparatus.
(D) An elaborate corona.

50. In the floral formula ⊕ ☿ K(5) C(5) A5 G(2), what does G(2) signify?
(A) Gynoecium of two fused carpels with a superior ovary.
(B) Gynoecium of two free carpels with a superior ovary.
(C) Gynoecium of two fused carpels with an inferior ovary.
(D) Gynoecium of two free carpels with an inferior ovary.

51. Within the rules of botanical nomenclature, what is a holotype?
(A) Any specimen illustrated in the original publication of a new plant species.
(B) A specimen collected from the original location at a significantly later date.
(C) The specimen or illustration designated by the author as the nomenclatural type.

(D) A duplicate specimen of the lectotype.

52. The characteristic large inflorescence of Musa (banana) is a type of:
(A) Simple raceme
(B) Panicle of spikelets
(C) Verticillaster
(D) Compound spadix or drooping spike

53. Which statement correctly describes a primitive feature commonly found in the family Magnoliaceae?
(A) Flowers are epigynous with a syncarpous gynoecium.
(B) Perianth is highly reduced or absent.
(C) An elongated floral axis bearing spirally arranged stamens and carpels.
(D) Flowers are zygomorphic and parts are in multiples of three.

54. Consider the following statements about placentation.
Statement I: In axile placentation, the ovules are borne on a central column in an ovary with multiple locules.
Statement II: In parietal placentation, the ovules are borne on the inner wall of a unilocular ovary.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

55. Match List I with List II.
List I: (Traditional Order)
P. Tubiflorales,
Q. Centrospermales,
R. Helobiales,
S. Ranales
List II: (Key Characteristic)
1. Aquatic herbs,
2. Primitive flowers,
3. Gamopetalous corolla,
4. Campylotropous ovules
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-3, Q-2, R-4, S-1

56. Modern trends in taxonomy utilize evidence from various fields. Which of the following is NOT a field of study that provides data for plant systematics?
(A) Astrology
(B) Palynology
(C) Cytology
(D) Phytochemistry

57. A flower that can be divided by only one vertical plane into two mirror-image halves is described using which term?
(A) Actinomorphic
(B) Asymmetric
(C) Zygomorphic
(D) Isomerous

58. Consider the following Assertion and Reason.
Assertion (A): The family Poaceae is arguably the most economically important plant family to humanity.
Reason (R): It provides the world's major staple foods, including wheat, rice, maize, and barley.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

59. Which of the following is an incorrect statement regarding the family Liliaceae?
(A) They are mostly perennial herbs propagating by bulbs, corms, or rhizomes.
(B) The flower is trimerous, with a perianth of six tepals.
(C) The gynoecium is tricarpellary with a superior ovary and axile placentation.
(D) The fruit is always a legume.

60. The conduplicate carpel theory explains the evolution of the angiosperm carpel as originating from the:
(A) Fusion and sterilization of multiple stamens.
(B) Inward folding of a megasporophyll along its midrib to enclose the ovules.
(C) Swelling and modification of the floral receptacle.
(D) Reduction of a complex branch system into a single unit.

61. Consider the following statements about taxonomic hierarchy:

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1. Kingdom is the highest and most inclusive rank.
2. Similarity decreases as we ascend from species to kingdom.
3. A genus is an assemblage of related families.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

62. What is the fundamental principle of serotaxonomy?
(A) The number and morphology of chromosomes are similar in closely related species.
(B) The structure of pollen grains provides clues to taxonomic relationships.
(C) The profile of secondary chemical compounds is a reliable indicator of phylogeny.
(D) Protein similarity is reflected by precipitation reactions between antigens and antibodies.

63. Identify the correct pair of a common plant and its botanical family.
(A) Pea - Fabaceae
(B) Sunflower - Rubiaceae
(C) Tomato - Papaveraceae
(D) Onion - Araceae

64. Arrange the following in correct chronological order.
1. Bentham and Hooker,
2. Linnaeus,
3. APG IV,
4. Engler and Prantl

(A) 2, 1, 4, 3
(B) 1, 2, 4, 3
(C) 2, 4, 1, 3
(D) 4, 2, 1, 3

65. Cause: A plant population is geographically isolated. Effect: The population diverges and becomes a distinct species endemic to that area. Which of the following is true?
(A) The effect is the reason for the cause.
(B) The cause is a primary driver of the effect.
(C) The cause and effect are entirely independent phenomena.
(D) Endemism would have occurred even without geographical isolation.

66. Consider the following statements about the family Araceae.
Statement I: The characteristic inflorescence is a spadix subtended by a prominent spathe.
Statement II: All members of the Araceae family are large trees found in temperate forests.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

67. Identify the incorrect pairing of a taxonomic group/order and a family.
(A) Ranales - Ranunculaceae
(B) Tubiflorales - Solanaceae
(C) Amentiferae - Fabaceae
(D) Helobiales - Alismataceae

68. Match List I with List II.
List I: (Botanical Term)
P. Gamopetalous,
Q. Epipetalous,
R. Syncarpous,
S. Hypogynous

List II: (Description)
1. Fused to petals,
2. Ovary superior,
3. Petals fused,
4. Carpels fused

(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

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69. In many species of Acanthaceae, the fruit is a capsule that dehisces explosively. This dispersal is aided by a hook-like structure called the:
(A) Pappus
(B) Elater
(C) Jaculator (Retinaculum)
(D) Aril

70. A field botanist collects a palm frond that is too large for a standard herbarium sheet. What is the professionally accepted method for preparation?
(A) Discard the specimen and look for a significantly smaller plant of the same species.

(B) Cut representative portions of the frond and arrange them with detailed notes.
(C) Fold the frond repeatedly like a fan until it fits the standard paper dimensions.
(D) Use a very large, non-standard paper size despite filing difficulties in herbaria.

71. Consider the following Assertion and Reason.
Assertion (A): The seeds of Orchidaceae are minute and lack significant food reserves.
Reason (R): Germination is critically dependent on nutrients from a symbiotic mycorrhizal fungus.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

72. Which statement identifies a distinguishing characteristic of the family Verbenaceae compared to Lamiaceae?
(A) The style is terminal on an unlobed or shallowly lobed ovary.
(B) The stem is always distinctly square in cross-section.
(C) The inflorescence is always a verticillaster.
(D) All members possess milky latex and a gynostegium.

73. Which of the following is NOT considered a merit of phylogenetic systems of classification?
(A) They provide a framework that reflects evolutionary history.
(B) They have strong predictive power regarding organism properties.
(C) They are perfectly stable and do not require revision regardless of new data.
(D) They help in understanding speciation and character evolution.

74. Consider the following statements about the family Dipterocarpaceae:
1. They are large, resinous trees that are keystone species in Asia.
2. The fruit is a nut-like achene surrounded by wing-like persistent sepals.
3. The flowers are small, zygomorphic, and arranged in heads.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

75. Palynology is primarily concerned with the study of:
(A) The anatomy of secondary wood.
(B) The chemical constituents of plant cells.
(C) The number, size, and form of chromosomes.
(D) The morphology, structure, and distribution of pollen and spores.

76. A key physiological characteristic of many plants in the order Santales is their:
(A) Fully autotrophic nature through enhanced photosynthesis.
(B) Hemi-parasitic or parasitic nature with haustorial connections.
(C) Saprophytic habit, deriving nutrients from decaying matter.
(D) Carnivorous habit, trapping and digesting insects.

77. Two botanists publish different names for the same species in 1890 and 1905. According to the Principle of Priority, which name should be recognized?
(A) The name published in 1905, because it represents the most recent findings.
(B) A completely new name must be proposed by a third independent botanist.
(C) The name published in 1890, because it is the earliest legitimate name.
(D) The name that is found to be shorter and significantly easier to pronounce.

78. Match List I with List II.
List I: (Specialized Structure)
P. Gynostegium,
Q. Cyathium,
R. Gynobasic style,
S. Tetradynamous stamens
List II: (Family)
1. Brassicaceae,
2. Lamiaceae,
3. Euphorbiaceae,
4. Asclepiadaceae
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1

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(D) P-3, Q-4, R-1, S-2

79. Which statement regarding the family Rutaceae is incorrect?
(A) Leaves are typically dotted with pellucid glands containing essential oils.
(B) A prominent nectariferous disc is usually present.
(C) The characteristic fruit in Citrus is a hesperidium.
(D) The fruit is exclusively a legume that splits on two sides.

80. Consider the following statements.
Statement I: Natural systems of classification are based on overall similarity in morphology.
Statement II: Phylogenetic systems are based on evolutionary relationships using molecular data.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

81. The APG IV classification system organizes flowering plants into major clades such as:
(A) Archichlamydeae, Sympetalae, and Monochlamydeae.
(B) Basal angiosperms, Magnoliids, Monocots, and Eudicots.
(C) Thallophyta, Embryophyta, and Spermatophyta.
(D) Lignosae and Herbaceae.

82. Arrange the following stages of floral development in sequence.
1. Organ primordia
2. Induction
3. Anthesis
4. Differentiation
(A) 1, 2, 3, 4
(B) 2, 1, 4, 3
(C) 2, 4, 1, 3
(D) 3, 2, 1, 4

83. Consider the following Assertion and Reason.
Assertion (A): Flowers in the family Cucurbitaceae are typically unisexual.
Reason (R): This floral structure promotes out-crossing and is an adaptation for entomophily.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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84. Basal placentation is a type of ovule arrangement characterized by:
(A) Ovules attached to a central axis in a multilocular ovary.
(B) Ovules attached to the inner peripheral wall of the ovary.
(C) Ovules attached in rows along the ventral suture of the carpel.
(D) One or a few ovules attached to the base of a unilocular ovary.

85. All of the following are considered essential taxonomic resources EXCEPT:
(A) Herbaria
(B) Botanical Gardens
(C) Horticultural trade fairs
(D) Taxonomic Literature and Floras

86. Consider the following characteristics:
1. Trimerous flowers,
2. Taproot system,
3. Parallel venation
Which of the above are characteristic of the class Monocotyledonae?
(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

87. Besides pulses, the family Fabaceae is also of major economic importance for providing:
(A) Major cereal grains like rice and wheat.
(B) Spices like cinnamon and clove.
(C) Aromatic essential oils like mint and basil.
(D) Forage crops and timber from trees like rosewood.

88. Which of the following is a key characteristic of the traditional order Tubiflorales?
(A) A sympetalous (gamopetalous) corolla, typically forming a tube.
(B) An apocarpous gynoecium with numerous free carpels.
(C) The presence of a catkin inflorescence with

apetalous flowers.
(D) An inferior ovary with parietal placentation and unisexual flowers.

89. A taxonomist comparing vascular bundles and stomata types is using:
(A) Cytological evidence
(B) Palynological evidence
(C) Anatomical (Histological) evidence
(D) Serological evidence

90. Match List I with List II.
List I: (Family)
P. Poaceae,
Q. Asteraceae,
R. Cucurbitaceae,
S. Rosaceae
List II: (Fruit Type)
1. Cypsela,
2. Pepo,
3. Caryopsis,
4. Drupe/Pome
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

91. Which of the following is NOT a fundamental principle of the ICN?
(A) Botanical nomenclature is independent of zoological nomenclature.
(B) Names of taxonomic groups are determined by nomenclatural types.
(C) Each taxonomic group can bear only one correct name.
(D) Names must be descriptive Latin phrases reflecting characteristics.

92. Consider the following statements about the family Rosaceae.
Statement I: Ovary position varies from superior to fully inferior.
Statement II: A hypanthium is common and related to ovary position variation.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

93. In modern chemotaxonomy, which analytical technique is most powerful?
(A) Simple acid-base titration
(B) Staining and light microscopy
(C) High-Performance Liquid Chromatography (HPLC)
(D) Measuring the electrical conductivity of plant sap

94. Consider the following Assertion and Reason.
Assertion (A): Stamen evolution shows a trend from leaf-like structures to filament and anther.
Reason (R): This trend reflects selection for more efficient pollen dispersal.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

95. In a taxonomic context, a natural history museum's botanical section primarily serves as a repository for:
(A) Preserved plant specimens (fluid or dry) for research and reference.
(B) Living plants for ex-situ conservation.
(C) Seed banks for long-term genetic preservation only.
(D) A collection of books on horticulture.

96. Catharanthus roseus is of medicinal importance as a source of:
(A) A high-protein edible seed.
(B) The anti-cancer alkaloids vincristine and vinblastine.
(C) A strong fiber used for textiles.
(D) A fragrant essential oil used in perfumery.

97. Identify the correct pair of a family and its prominent distinguishing feature.
(A) Apiaceae - Monadelphous stamens
(B) Euphorbiaceae - Cyathium inflorescence
(C) Malvaceae - Inferior ovary
(D) Musaceae - Tetradynamous stamens

98. Consider the merits of Bentham and Hooker's system:
1. It is a true phylogenetic system.
2. It has practical value for identification.
3. Placement of Gymnospermae is a major

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demerit.
Which of the above statement(s) is/are correct?
(A) 2 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

99. The order Centrospermales (Caryophyllales) is characterized by all EXCEPT:
(A) The presence of betalain pigments instead of anthocyanins.
(B) Placentation that is typically free-central or basal.
(C) A gynoecium that is consistently apocarpous with numerous free carpels.
(D) Ovules that are campylotropous or amphitropous.

100. A flower with five fused petals, five epipetalous stamens, and an obliquely placed superior ovary belongs to:
(A) Ranunculaceae
(B) Brassicaceae
(C) Poaceae
(D) Solanaceae

101. The collective term for all the stamens in a flower is the:
(A) Gynoecium
(B) Perianth
(C) Androecium
(D) Calyx

102. The family Dipterocarpaceae is the primary source of:
(A) Edible nuts and oils
(B) Tropical hardwood timber (meranti)
(C) Potent medicinal alkaloids
(D) Natural rubber

103. Which statement correctly describes the floral unit of the Poaceae family?
(A) The flower is large, showy, and typically pentamerous.
(B) The floret is enclosed by two bracts, the lemma and the palea.
(C) The perianth consists of five distinct sepals and five petals.
(D) The fruit is a drupe with a highly succulent mesocarp layer.

104. Consider the following statements about embryology in taxonomy.
Statement I: Embryological characters can provide valuable taxonomic evidence.
Statement II: These characters are useful in determining relationships at higher taxonomic levels.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

105. Match List I with List II.
List I: (Common Name)
P. Potato,
Q. Cotton,
R. Lentil,
S. Sunflower
List II: (Family)
1. Fabaceae,
2. Asteraceae,
3. Solanaceae,
4. Malvaceae
(A) P-3, Q-4, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-1, Q-2, R-3, S-4

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106. All of the following are typically characteristic of the family Ranunculaceae EXCEPT:
(A) Predominantly herbaceous habit.
(B) A syncarpous gynoecium with a single compound pistil.
(C) Numerous, spirally arranged stamens.
(D) A superior ovary.

107. A dichotomous key is based on:
(A) A long narrative description of each species.
(B) A complex phylogenetic tree showing relationships.
(C) A geographical map showing distributions.
(D) A sequence of paired, contrasting statements (couplets).

108. Consider the following Assertion and Reason.
Assertion (A): Many members of Santales are parasitic or hemi-parasitic.
Reason (R): They develop specialized absorptive organs called haustoria.
(A) Both A and R are true and R is the correct

154. Consider statements about modern systematics.
Statement I: Molecular phylogenetics shows "dicots" are not monophyletic.
Statement II: The APG system recognizes a large monophyletic Eudicot clade.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

155. Which statement about the family Magnoliaceae is incorrect?
(A) The gynoecium is syncarpous, and the ovary is inferior.
(B) It is widely considered to represent a primitive lineage.
(C) Floral parts are often numerous and spiral.
(D) The perianth is often undifferentiated into tepals.

156. For a botanist, the most valuable function of a regional Flora is to:
(A) Provide a comprehensive list of all local vernacular names for plants.
(B) Provide diagnostic keys and descriptions for accurate identification.
(C) Offer detailed horticultural instructions on how to cultivate native plants.
(D) Document the entire evolutionary history and phylogeny of each species.

157. Nutritive tissue derived from the nucellus is known as:
(A) Pericarp
(B) Cotyledon
(C) Perisperm
(D) Aril

158. The family Apiaceae includes root vegetables such as:
(A) Radish and turnip
(B) Potato and sweet potato
(C) Onion and garlic
(D) Carrot and parsnip

159. Which statement correctly describes Orchidaceae diversity?
(A) All orchids are terrestrial herbs.
(B) The family is exclusively composed of epiphytes.
(C) It is cosmopolitan, including terrestrial, epiphytic, and saprophytic habits.
(D) All orchids are root parasites.

160. Consider definitions of stamen fusion.
Statement I: Monadelphous means filaments are fused into one tube.
Statement II: Syngenesious means anthers are fused, filaments are free.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

161. Pollinia are key characteristics of which two families?
(A) Poaceae and Cyperaceae
(B) Asclepiadaceae and Orchidaceae
(C) Fabaceae and Rosaceae
(D) Ranunculaceae and Papaveraceae

162. Identify the incorrect pair of a botanical term and its definition.
(A) Gamosepalous - A calyx composed of sepals that are free from one another.
(B) Sessile - Describing a leaf or flower that lacks a stalk.
(C) Pedicellate - A flower that is borne on a stalk.
(D) Apocarpous - A gynoecium composed of two or more free carpels.

163. An achene is a dry, indehiscent fruit characterized by:
(A) Having a pericarp that extends into a wing.
(B) Having the seed coat fused to the pericarp.
(C) Containing a single seed attached at only one point.
(D) Being derived from an inferior ovary.

164. A square stem in cross-section is a common feature for:
(A) Apiaceae
(B) Poaceae
(C) Rosaceae
(D) Lamiaceae

165. What is a key characteristic of Rubiaceae stipules?
(A) They are consistently absent.

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4. Chromosomes
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

119. The fruit of Papaver dehisces by:
(A) Splitting longitudinally from base to apex.
(B) A lid separating transversely (circumscissile).
(C) A series of pores opening below the persistent stigma.
(D) Explosively breaking into several valves.

120. In the floral formula K(5) C(5) A(∞) G(5), what is correct?
(A) The ovary is inferior and consists of 5 separate carpels.
(B) There are infinite stamens, all fused into a single tube.
(C) The corolla has 5 free petals, and the gynoecium is superior.
(D) The calyx consists of 5 fused sepals and the gynoecium of 5 fused carpels.

121. Consider the following Assertion and Reason.
Assertion (A): Pollination in Asclepiadaceae is a specialized process.
Reason (R): It involves the transfer of pollinia by a translator apparatus.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

122. Which represents a major evolutionary trend in angiosperms?
(A) A general shift from woody to herbaceous habits.
(B) A trend towards reduction and fusion of floral parts.
(C) A change from having an inferior to a superior ovary.
(D) An increase in the number of spiral floral parts.

123. The family Solanaceae does NOT provide:
(A) Food staples like potato and eggplant.
(B) Psychoactive and medicinal drugs like atropine.
(C) Spices like chili peppers.
(D) Major commercial timbers like teak and mahogany.

124. Which requirements for valid publication are mandatory?
1. Description/Diagnosis
2. Nomenclatural type
3. Effective publication
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

125. What is the full form of the acronym GIS?
(A) Genetic Information Sequence
(B) Global Identification of Species
(C) Geographic Information System
(D) General Index of Systematics

126. Tendrils in Cucurbitaceae are generally considered modified:
(A) Leaflets of a compound leaf
(B) Stipules, bracts, or axillary shoots
(C) Adventitious roots arising from the nodes
(D) Petioles of a reduced leaf

127. A scientist studying naming and evolutionary relationships is engaged in:
(A) Ethnobotany
(B) Horticulture
(C) Plant Physiology
(D) Plant Systematics

128. An herb with a square stem, bilabiate corolla, and a gynobasic style belongs to:
(A) Lamiaceae
(B) Verbenaceae
(C) Solanaceae
(D) Acanthaceae

129. Which statement incorrectly describes a Fabaceae subfamily?
(A) Papilionoideae: Flowers zygomorphic; stamens often diadelphous.
(B) Caesalpinioideae: Imbricate (ascending) aestivation of corolla.
(C) All three have tetradynamous stamens and siliqua fruit.
(D) Mimosoideae: Flowers actinomorphic; stamens numerous.

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130. Consider the following statements about cytology in taxonomy.
Statement I: Basic chromosome number can be uniform across a genus.
Statement II: Polyploidy has been a major mechanism of evolution.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

131. What is the primary demerit of Bentham and Hooker's system?
(A) It is excessively complex for practical identification.
(B) It completely ignores gymnosperms and non-flowering plants.
(C) It is based on an insufficient number of morphological characters.
(D) It does not group taxa according to their phylogenetic relationships.

132. The gynostemium in an orchid is formed by the fusion of the:
(A) Calyx and corolla
(B) Stamens, style, and stigma
(C) Ovary and receptacle
(D) Pedicel and thalamus

133. The edible part of an apple is known as a:
(A) Drupe
(B) Berry
(C) Pome
(D) Nut

134. Which statement is correct for the family Araceae?
(A) Flowers are always large and bisexual.
(B) The inflorescence is a panicle of spikelets.
(C) All members are wind-pollinated, tall trees.
(D) Many members contain calcium oxalate raphides.

135. All of the following are types of placentation found in angiosperms EXCEPT:
(A) Coronary
(B) Axile
(C) Parietal
(D) Free-central

136. If a holotype is lost, a specimen selected from original material is called a:
(A) Neotype
(B) Lectotype
(C) Isotype
(D) Paratype

137. Identify the incorrect pair of a traditional order and general characteristic.
(A) Ranales - Apocarpous gynoecium is common.
(B) Amentiferae - Flowers are large and insect-pollinated.
(C) Tubiflorales - Gamopetalous corolla is characteristic.
(D) Helobiales - Members are typically aquatic or marsh plants.

138. Consider the following statements.
Statement I: Induction is the first step where the apex commits to flowering.
Statement II: The ABC model describes gene activity specifying identity.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

139. In botanical nomenclature, what is a Lectotype?
(A) Any specimen that is a duplicate of the holotype.
(B) A specimen selected when all original material is missing.
(C) A specimen selected from original material when a holotype was not designated or is lost.
(D) Any specimen cited other than the holotype or isotype.

140. Okra and Hibiscus (Malvaceae) have a slimy texture due to:
(A) Irritating milky latex
(B) Aromatic essential oils
(C) Potent alkaloids
(D) Mucilage

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141. A common feature of the Acanthaceae inflorescence is:
(A) Presence of a cyathium.
(B) Arrangement of flowers in spikelets.

(C) Presence of prominent bracts and bracteoles.
(D) Total absence of a perianth.

142. Which source of evidence is LEAST emphasized in the APG system compared to earlier systems?
(A) DNA sequences from plastid genes such as rbcL and matK.
(B) Overall phenetic similarity without assessing homology of characters.
(C) DNA sequences from nuclear ribosomal DNA like the ITS region.
(D) Data from anatomy and chemistry interpreted in a phylogenetic context.

143. Charles Darwin's phrase "an abominable mystery" referred to:
(A) The mechanism of double fertilization.
(B) The diversity of secondary metabolites.
(C) The ability of plants to be carnivorous.
(D) The sudden appearance of flowering plants in the fossil record.

144. An herb with a cruciform corolla and tetradynamous stamens belongs to:
(A) Brassicaceae
(B) Fabaceae
(C) Solanaceae
(D) Malvaceae

145. Identify the incorrect pairing regarding typical ovary position.
(A) Ranunculaceae - Superior
(B) Asteraceae - Inferior
(C) Cucurbitaceae - Superior
(D) Lamiaceae - Superior

146. Consider the statements comparing Verbenaceae and Lamiaceae.
Statement I: Both belong to Lamiales and have opposite leaves.
Statement II: Lamiaceae has a gynobasic style; Verbenaceae has terminal.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

147. In the botanical name Solanum tuberosum L., the L. signifies:
(A) The species is large-flowered.
(B) The name is Legitimate.
(C) Linnaeus, the author.
(D) Native to Latin America.

148. Parthenocarpic banana fruit develops without:
(A) Pollination
(B) Photosynthesis
(C) Transpiration
(D) Fertilization

149. Which correctly describes the cyathium inflorescence in Euphorbia?
(A) Cup-shaped involucre enclosing one female and several male flowers.
(B) A fleshy spike bearing numerous unisexual flowers.
(C) A dense head of small bisexual florets.
(D) A dichasial cyme with flowers in pairs.

150. The perianth consists of all the following floral parts EXCEPT:
(A) Sepals
(B) Stamens
(C) Petals
(D) Tepals

151. In an epigynous flower, the ovary is described as inferior because:
(A) It has significantly fewer ovules than a typical superior ovary.
(B) It is composed of a single, structurally simple carpel.
(C) The hypanthium is adnate to the ovary with parts attached above it.
(D) It develops into a dry, dehiscent fruit at maturity.

152. The wings in Dipterocarpaceae fruits are outgrowths of the:
(A) Petals
(B) Bracts
(C) Styles
(D) Sepals

153. If your specimen has an inferior ovary, which family can you rule out?
(A) Asteraceae
(B) Cucurbitaceae
(C) Solanaceae
(D) Rubiaceae

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Statement II: A cypsela is a single-seeded dry fruit from an inferior ovary.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

179. In botanical nomenclature, a paratype is:
(A) The single specimen designated as type.
(B) A new type designated when original is lost.
(C) A specimen cited in the protologue that is not the holotype or isotype.
(D) A specimen illustrating variation.

180. Betalain pigments are marker for families in the order:
(A) Ranales
(B) Tubiflorales
(C) Amentiferae
(D) Centrospermales (Caryophyllales)

181. Which is a salient feature of the ICBN?
(A) Names are determined by nomenclatural types.
(B) Names must be long, descriptive polynomials.
(C) Starting point is 1737.
(D) Common names have priority.

182. Poaceae characteristics include all EXCEPT:
(A) Stems are hollow culms.
(B) Flowers are large, brightly colored, and pentamerous.
(C) Leaves consist of a sheath and ligule.
(D) Inflorescence of spikelets.

183. The greatest advantage of APG IV over Bentham and Hooker is that APG IV:
(A) Is found to be much simpler for a novice to use for field identification.
(B) Is based on a single, easily observable and measurable character.
(C) Intentionally reflects evolutionary history using extensive DNA evidence.
(D) Is an unchanging classification that will never require future revision.

184. Inferior ovary is a key feature of:
(A) Solanaceae
(B) Brassicaceae
(C) Liliaceae
(D) Asteraceae

185. Identify the incorrect pair of family and placentation.
(A) Asteraceae - Axile
(B) Fabaceae - Marginal
(C) Solanaceae - Axile
(D) Brassicaceae - Parietal

186. Consider Assertion and Reason about grasses.
Assertion (A): Poaceae is adapted for anemophily.
Reason (R): Characteristics include reduced perianth and feathery stigmas.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

187. A hesperidium is a specialized type of:
(A) Drupe
(B) Pome
(C) Aggregate
(D) Berry

188. A spadix subtended by a spathe is characteristic of:
(A) Araceae
(B) Poaceae
(C) Orchidaceae
(D) Rosaceae

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189. Which statement about Angiosperm systematics is correct?
(A) Relationships are now fully understood.
(B) Only goal is a correct name.
(C) It is an integrative science building hypotheses of relationships.
(D) All phylogenetic systems are identical.

190. Which of the following is NOT considered a primitive floral character?
(A) A sympetalous corolla with fused petals forming a tube.
(B) Numerous floral parts with an indefinite number.
(C) An apocarpous gynoecium with free carpels.
(D) Spirally arranged floral parts.

(B) They are modified into sharp spines.
(C) They are interpetiolar.
(D) They are modified into tendrils.

166. Which is cited as a challenge of modern phylogenetic systems?
(A) They are based on common descent.
(B) Relationship classifications may change as new molecular data is analyzed.
(C) They have high predictive power.
(D) They provide testable hypotheses.

167. The purpose of using precise botanical terms (semi-technical language) is to:
(A) Make the field of botany seem more exclusive and difficult for amateurs.
(B) Ensure clarity, accuracy, and universal understanding among scientists.
(C) Fulfill a complex legal requirement for naming every new species.
(D) Create descriptions that are found to be aesthetically pleasing to readers.

168. A hallmark of the family Malvaceae is:
(A) Staminal tube (monadelphous).
(B) Tetradynamous stamens.
(C) Syngenesious stamens.
(D) Spikelet inflorescence.

169. Which statement about the Poaceae perianth is incorrect?
(A) Lodicules swell to open the flower.
(B) It is reduced to minute scales called lodicules.
(C) It is large and colourful to attract insects.
(D) It is not differentiated into calyx and corolla.

170. Consider statements about taxonomic tools.
Statement I: Herbaria provide morphological and geographical information.
Statement II: Botanical gardens house dried, preserved specimens.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

171. In botanical nomenclature, a neotype is:
(A) The very first specimen of a new species ever collected by a botanist.
(B) A duplicate specimen of the designated holotype.
(C) A specimen selected from original material when no holotype was designated.
(D) A specimen selected when all original material of the name is lost.

172. A gynobasic style is a characteristic feature of:
(A) Solanaceae
(B) Lamiaceae
(C) Rubiaceae
(D) Malvaceae

173. Which correctly describes Cucurbitaceae placentation?
(A) Axile placentation in a superior ovary.
(B) Basal placentation with a single ovule.
(C) Parietal placentation in an inferior ovary.
(D) Free-central placentation in a superior ovary.

174. Each is correctly matched EXCEPT:
(A) Poaceae - Cereals
(B) Fabaceae - Pulses
(C) Rutaceae - Citrus
(D) Dipterocarpaceae - Spices

175. The most significant adaptive advantage of the flower is:
(A) It facilitates efficient transfer of pollen through targeted mechanisms.
(B) It increases the rate of transpiration.
(C) It is the primary site for photosynthesis.
(D) It offers protection against large herbivores.

176. A plant with a cruciform corolla and six stamens cannot belong to:
(A) Brassicaceae
(B) Fabaceae
(C) Cruciferae
(D) The mustard family

177. Identify the incorrect pairing of family and symmetry.
(A) Brassicaceae - Actinomorphic
(B) Lamiaceae - Zygomorphic
(C) Malvaceae - Zygomorphic
(D) Papilionoideae - Zygomorphic

178. Consider statements about Asteraceae fruit.
Statement I: The fruit is a cypsela.

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explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

109. Which statement about the order Helobiales is generally considered incorrect?
(A) It is regarded as primitive among monocotyledons.
(B) The gynoecium is frequently apocarpous.
(C) It comprises predominantly terrestrial desert plants.
(D) The families are mostly aquatic herbs.

110. The evolutionary trend in the gynoecium is generally characterized by:
(A) Reduction in carpel number and increased fusion (syncarpy).
(B) A change from fused carpels to free carpels.
(C) A consistent increase in the number of carpels and ovules.
(D) A shift from an inferior ovary position to a superior one.

111. Consider the following statements about the family Asteraceae:
1. Inflorescence is a capitulum.
2. Stamens are syngenesious.
3. The fruit is a fleshy drupe.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

112. In botanical nomenclature, a tautonym (e.g., Linaria linaria) is:
(A) Permitted and encouraged for simplicity.
(B) Explicitly forbidden and considered illegitimate.
(C) Permitted only for species named before 1753.
(D) Mandatory for all type species of a genus.

113. Identify the correct pair of a family and its characteristic inflorescence type.
(A) Apiaceae - Cyathium
(B) Lamiaceae - Umbel
(C) Araceae - Spadix
(D) Euphorbiaceae - Verticillaster

114. Arrange the steps of the formal taxonomic process:
1. Publication
2. Designating holotype
3. Comparison
4. Conclusion
(A) 2, 3, 4, 1
(B) 1, 2, 3, 4
(C) 2, 4, 3, 1
(D) 3, 4, 1, 2

115. Cause: Flowers of Lamiaceae are often bilabiate.
Effect: This provides a landing platform for bees.
Which of the following is true?
(A) The effect is an adaptive advantage of the causal structure.
(B) The cause is a result of the effect.
(C) The cause and effect are completely unrelated.
(D) This floral structure is designed to prevent all insect visits.

116. Consider the following statements about Brassicaceae.
Statement I: The androecium is described as tetradynamous.
Statement II: Tetradynamous means four long inner and two short outer stamens.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

117. Identify the incorrect pairing of a plant and its product.
(A) Oryza sativa - Cereal grain
(B) Glycine max - High-quality timber
(C) Citrus limon - Fruit/Essential oil
(D) Papaver somniferum - Latex

118. Match List I with List II.
List I: (Evidence)
P. Molecular,
Q. Cytological,
R. Palynological,
S. Anatomical
List II: (Example)
1. Pollen,
2. Stomata,
3. DNA,

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191. Which piece of label information is most critical for biodiversity studies?
(A) The local common name of the plant.
(B) The name of the person who mounted the specimen.
(C) The pH of the soil where the plant was growing.
(D) The precise locality and date of collection.

192. The formula K(5), C1+2+(2), A(9)+1, G1 represents:
(A) Asteraceae
(B) Papilionoideae
(C) Solanaceae
(D) Brassicaceae

193. Identify the incorrect pairing of plant and family.
(A) Triticum aestivum - Poaceae
(B) Rosa indica - Rosaceae
(C) Coffea arabica - Solanaceae
(D) Daucus carota - Apiaceae

194. Consider statements about placentation evolution.
Statement I: Axile evolved from parietal.
Statement II: Free-central derived from axile.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

195. In botanical nomenclature, an isotype is:
(A) Any duplicate specimen of the holotype.
(B) The single specimen designated as definitive.
(C) A specimen chosen from original material.
(D) A new specimen chosen when original is lost.

196. An umbel inflorescence is characteristic of:
(A) Lamiaceae
(B) Apiaceae
(C) Asteraceae
(D) Poaceae

197. Which statement contrasts natural and phylogenetic systems?
(A) Natural systems are arbitrary.
(B) Natural systems rely only on molecular data.
(C) Natural systems group by overall similarity; phylogenetic by ancestry.
(D) Natural systems are no longer used.

198. Which family does NOT fit the description of Tubiflorales?
(A) Solanaceae
(B) Verbenaceae
(C) Lamiaceae
(D) Rubiaceae

199. Syngenesious stamens in Asteraceae create a mechanism for:
(A) Explosive fruit dehiscence
(B) Nectar secretion
(C) Secondary pollen presentation
(D) Protection of ovules

200. Oils from sunflower, soybean, and rapeseed come from:
(A) Asteraceae, Fabaceae, and Brassicaceae
(B) Poaceae, Rosaceae, and Solanaceae
(C) Rutaceae, Lamiaceae, and Euphorbiaceae
(D) Liliaceae, Musaceae, and Araceae

201. The concept of species as a 'dynamic lineage' is central to the:
(A) Morphological Concept
(B) Evolutionary Concept
(C) Biological Concept
(D) Nominalistic Concept

202. Which is a primary demerit of the Bentham and Hooker system?
(A) Placement of Gymnosperms between Dicots and Monocots.
(B) Based on too few characters.
(C) It is too complex as a phylogenetic system.
(D) Ignored economic importance.

203. A flower with an undifferentiated perianth has:
(A) Bracts
(B) Lodicules
(C) Tepals
(D) Stipules

204. Consider statements about Orchidaceae.
Statement I: Flowers are zygomorphic with a labellum.
Statement II: Ovary is superior and apocarpous.
Which of the above statement(s) is/are correct?

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ANSWERS

1. (B) The arrangement of ovules within the ovary.
Placentation describes the specific pattern in which ovules are attached to the placenta within the ovary of a flower. This arrangement varies significantly across different plant families, serving as a vital diagnostic character in plant taxonomy. Common types include marginal, axile, parietal, and basal, each reflecting the evolutionary adaptation of the gynoecium for efficient seed development and dispersal.

2. (A) To provide a stable and universal system for naming taxonomic groups of plants.
The International Code of Nomenclature for algae, fungi, and plants establishes a standardized framework for naming plant taxa. Its primary goal is to ensure that each taxonomic group has only one globally recognized name, thereby preventing confusion and providing stability. By following strictly defined rules and principles, botanists can communicate accurately regarding plant identification and evolutionary relationships across different regions.

3. (C) The gynoecium is typically apocarpous with numerous carpels on an elongated receptacle.
The family Ranunculaceae is characterized by several primitive floral features that distinguish it from more advanced plant groups. One defining trait is the presence of an apocarpous gynoecium, where multiple distinct carpels are arranged spirally on a prominent floral axis or receptacle. This ancestral condition is often accompanied by numerous stamens and a predominantly herbaceous growth habit in most species.

4. (C) Statement I is true but Statement II is false.
Floral induction represents the complex physiological shift where a vegetative shoot apical meristem transitions into a reproductive state. While genetic factors play a significant role in this developmental change, the process is heavily influenced by external environmental cues such as photoperiod and temperature. Therefore, claiming that induction is entirely independent of the surrounding environment is scientifically inaccurate in plant biology.

5. (A) P-3, Q-2, R-1, S-4
Different plant families exhibit distinct placentation types that aid in their identification and classification. Parietal placentation occurs in Brassicaceae, while axile placentation is characteristic of Solanaceae. Basal placentation is found in the Asteraceae family, where a single ovule is attached at the ovary base. Marginal placentation is the standard for Fabaceae, featuring ovules along the ventral suture of the carpel.

6. (B) Nursery for commercial plant propagation
Standard taxonomic tools are resources specifically designed to facilitate the identification, classification, and study of plant diversity. Herbaria, botanical gardens, and floras provide essential morphological data and reference materials for researchers. In contrast, commercial nurseries focus primarily on the mass production and sale of plants for landscaping or agriculture, rather than serving as rigorous scientific centers for systematic research.

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(D) Ranunculaceae
The described floral characteristics point directly to the Ranunculaceae family, which is known for its primitive and often numerous floral parts. Features like an actinomorphic symmetry, a superior ovary, and especially an apocarpous gynoecium with many free carpels on an elongated receptacle are classic identifiers. These traits distinguish it from more derived families like Asteraceae or Poaceae, which show fusion.

8. (A) Both A and R are true and R is the correct explanation of A.
The Angiosperm Phylogeny Group IV system represents a modern approach to classification by emphasizing evolutionary lineages. Unlike earlier systems based primarily on morphology, APG IV utilizes extensive molecular data, specifically DNA sequences from chloroplast and nuclear genomes. This methodology allows taxonomists to infer more accurate phylogenetic relationships, ensuring that grouped taxa share a common ancestor and reflect the true tree of life.

217. Identify the incorrect pair.
(A) Rutaceae - Citrus
(B) Orchidaceae - Cereal grains
(C) Musaceae - Banana
(D) Euphorbiaceae - Rubber

218. Match List I with List II.
List I: (Family)
P. Asteraceae,
Q. Lamiaceae,
R. Poaceae,
S. Apiaceae
List II: (Feature)
1. Ligule,
2. Compound umbel,
3. Syngenesious,
4. Gynobasic
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

219. A major alkaloid in opium is:
(A) Nicotine
(B) Caffeine
(C) Morphine
(D) Quinine

220. An herb with alternate leaves and obliquely placed superior ovary belongs to:
(A) Malvaceae
(B) Fabaceae
(C) Asteraceae
(D) Solanaceae

221. Consider Assertion and Reason.
Assertion (A): APG IV placement differs from Bentham and Hooker.
Reason (R): APG is phylogenetic; Bentham and Hooker is natural.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

222. Which is correct about Acanthaceae?
(A) Ovary is always inferior.
(B) Flowers are zygomorphic with conspicuous bracts.
(C) Fruit is a legume.
(D) All are trees with latex.

223. The law of priority states:
(A) Higher rank has priority.
(B) Descriptive names have priority.
(C) Earliest validly published name is correct.
(D) Prestigious journal publication has priority.

224. Which are diagnostic of Magnoliaceae?
1. Trees with conical stipules
2. soliary actinomorphic flowers
3. spiral parts
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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225. Primary role of museum in botany:
(A) Grow living plants.
(B) Sequence genomes.
(C) Repository for preserved specimens.
(D) Sell rare plants.

226. Which is NOT a characteristic of Musaceae?
(A) Pseudostem.
(B) Trimerous flowers.
(C) Drooping spadix.
(D) Ovary is superior.

227. A flower divisible by any vertical plane is:
(A) Actinomorphic
(B) Asymmetrical
(C) Zygomorphic
(D) Epigynous

228. Match List I with List II.
List I: (Product)
P. Cotton,
Q. Coffee,
R. Menthol,
S. Sal
List II: (Family)
1. Rubiaceae,
2. Dipterocarpaceae,
3. Malvaceae,
4. Lamiaceae
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-2, S-3

280. Key feature distinguishing Lamiaceae from Verbenaceae:
(A) Gynobasic style.
(B) Superior ovary.
(C) Simple leaves.
(D) Aromatic nature.

281. Consider Assertion and Reason.
Assertion (A): Capitulum is advanced.
Reason (R): Promotes cross-pollination.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

282. Histological techniques refer to study of:
(A) Fossils.
(B) Tissues and internal anatomy.
(C) Distribution.
(D) Behavior.

283. Which is NOT a monocot?
(A) Poaceae
(B) Liliaceae
(C) Ranunculaceae
(D) Orchidaceae

284. Which about carpel origin are correct?
1. Fertile leaf,
2. Folded,
3. Origin of fruit
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

285. In Mangifera indica Linn., indica is:
(A) Specific epithet
(B) Generic name
(C) Author name
(D) Family name

286. Replum is diagnostic of:
(A) Fabaceae
(B) Brassicaceae
(C) Solanaceae
(D) Papaveraceae

287. Direct use of Herbarium:
(A) Conservation.
(B) Germplasm source.
(C) Reference collection.
(D) Chemical analysis.

288. Match List I with List II.
List I: (Family)
P. Rosaceae,
Q. Rubiaceae,
R. Asteraceae,
S. Poaceae
List II: (Genus)
1. Coffea,
2. Triticum,
3. Prunus,
4. Helianthus
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-2, S-3

289. Engler and Prantl flaw:
(A) Single character.
(B) No monocots.
(C) Amentiferae as most primitive.
(D) Pre-Linnaean.

290. Column in Orchidaceae is fusion of:
(A) Sepals/petals.
(B) Pedicel/thalamus.
(C) Bracts/bracteoles.
(D) Androecium/gynoecium.

291. Consider Assertion and Reason.
Assertion (A): Dipterocarpaceae fruits are wind dispersed.
Reason (R): They are small nuts with wing-like sepals.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

292. In free-central placentation:
(A) Periphery.
(B) Central column in unilocular ovary.
(C) Base.
(D) Central column in multilocular ovary.

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(D) A is false but R is true.

242. Rutaceae leaf glands produce:
(A) Mucilage
(B) Aromatic essential oils
(C) Milky latex
(D) Potent poisons

243. Semi-technical language refers to:
(A) Simplified botanical descriptions.
(B) Language mix.
(C) Precise defined botanical terms.
(D) Molecular language.

244. Which about Rosaceae is correct?
1. Cosmopolitan,
2. Ovary always superior,
3. Hypanthium present
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

245. Labellum in orchid is a modified:
(A) Sepal
(B) Stamen
(C) Bract
(D) Petal

246. Opposite leaves with interpetiolar stipules and inferior ovary suggests:
(A) Rubiaceae
(B) Lamiaceae
(C) Apocynaceae
(D) Acanthaceae

247. Endemic species means:
(A) Disease resistant.
(B) Found only in a particular restricted area.
(C) Cultivated worldwide.
(D) Extinct.

248. Match List I with List II.
List I: (Fruit)
P. Caryopsis,
Q. Cypsela,
R. Hesperidium,
S. Legume
List II: (Family)
1. Rutaceae,
2. Fabaceae,
3. Poaceae,
4. Asteraceae
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

249. Merit of Bentham and Hooker's system:
(A) Reflects evolutionary pathways.
(B) Based on molecular data.
(C) Practical for identification.
(D) Monocot placement.

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250. Family of potato and tomato:
(A) Cucurbitaceae
(B) Fabaceae
(C) Brassicaceae
(D) Solanaceae

251. Consider Assertion and Reason.
Assertion (A): Santales has parasitic plants.
Reason (R): They lack chlorophyll.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

252. Apocarpy to syncarpy trend is advantageous as it:
(A) Increases seed number.
(B) Attracts pollinators.
(C) Allows efficient centralized pollen reception.
(D) Is primitive.

253. Technique based on antigen-antibody reaction:
(A) Cytology
(B) Serology
(C) Palynology
(D) Anatomy

254. Which about Papaveraceae are correct?
1. Latex present,
2. Syncarpous,
3. Parietal
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

229. Which correctly describes Rosaceae fruit?
(A) Always a siliqua.
(B) Consistently a caryopsis.
(C) Diverse (pome, drupe, achene).
(D) Capsule with pores.

230. A climbing plant with inferior ovary and pepo fruit suggests:
(A) Solanaceae
(B) Fabaceae
(C) Malvaceae
(D) Cucurbitaceae

231. Consider Assertion and Reason.
Assertion (A): Helobiales is primitive.
Reason (R): Members exhibit syncarpy.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

232. Correct evolutionary trend in stamens:
(A) From few to numerous.
(B) From laminar to filament and anther.
(C) From filament/anther to laminar.
(D) From free to fused to free.

233. Tubiflorales refers to flowers with:
(A) Parts in a tube.
(B) Stamens in a tube.
(C) Tubular, gamopetalous corolla.
(D) Style in a tube.

234. Which statements about Verbenaceae are correct?
1. Round stem, terminal style
2. Teak source
3. Never a verticillaster
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

235. Stamen-stigma fusion structure is:
(A) Column
(B) Gynobasic style
(C) Gynostegium
(D) Hypanthium

236. Which is NOT a technique in taxonomy?
(A) Phytochemistry
(B) Numerology
(C) Cytology
(D) Molecular biology

237. Pepo is characteristic of:
(A) Rosaceae
(B) Solanaceae
(C) Rutaceae
(D) Cucurbitaceae

238. Match List I with List II.
List I: (Family)
P. Apocynaceae,
Q. Araceae,
R. Euphorbiaceae,
S. Verbenaceae
List II: (Genus)
1. Ricinus,
2. Tectona,
3. Colocasia,
4. Catharanthus
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

239. Milky latex, cyathium, and three-chambered fruit are diagnostic of:
(A) Papaveraceae
(B) Apocynaceae
(C) Euphorbiaceae
(D) Asclepediaceae

240. Spikelets aggregated into terminal spikes are characteristic of:
(A) Asteraceae
(B) Liliaceae
(C) Araceae
(D) Poaceae

241. Consider Assertion and Reason.
Assertion (A): Brassicaceae is easily recognizable.
Reason (R): Features include cruciform corolla and tetradynamous stamens.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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(D) Antigen-antibody reactions.

268. Match List I with List II.
List I: (Order)
P. Ranales,
Q. Tubiflorales,
R. Amentiferae,
S. Helobiales
List II: (Family)
1. Lamiaceae,
2. Araceae,
3. Ranunculaceae,
4. Fagaceae
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-3, R-1, S-4

269. Family with umbel, schizocarp, and aromatic oils:
(A) Lamiaceae
(B) Asteraceae
(C) Apiaceae
(D) Brassicaceae

270. Which family is NOT characterized by inferior ovary?
(A) Brassicaceae
(B) Asteraceae
(C) Rubiaceae
(D) Cucurbitaceae

271. Consider Assertion and Reason.
Assertion (A): Poaceae has a fibrous root system.
Reason (R): This is typical of monocots where primary root is short-lived.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

272. A Monograph provides:
(A) List of plants.
(B) Comprehensive treatment of a particular taxon worldwide.
(C) Herbarium instructions.
(D) Medicinal uses.

273. Carpel evolution involved all EXCEPT:
(A) In-rolling.
(B) Fusion.
(C) Stigma development.
(D) Fusion with stamen.

274. Which statements about APG IV are correct?
1. Phylogenetic, 2. Molecular data, 3. Less stable
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

275. Which is incorrect about Apocynaceae?
(A) Latex present.
(B) Contorted aestivation.
(C) Fruit is a siliqua.
(D) Carpels fused at style.

276. Pappus is a modified:
(A) Corolla
(B) Androecium
(C) Involucral bract
(D) Calyx

277. Study of chromosomes in taxonomy is:
(A) Palynology
(B) Chemotaxonomy
(C) Cytotaxonomy
(D) Numerical Taxonomy

278. Match List I with List II.
List I: (Family)
P. Solanaceae,
Q. Fabaceae,
R. Brassicaceae,
S. Liliaceae
List II: (Formula feature)
1. K2+2 C4,
2. P3+3,
3. C1+2+(2),
4. K(5) C(5) A5
(A) P-4, Q-3, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

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279. Araceae importance:
(A) Timber.
(B) Starchy corms/tubers.
(C) Pulses.
(D) Essential oils.

(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

205. Palynology can be applied to:
(A) Cytotaxonomy
(B) Serotaxonomy
(C) Reconstructing past vegetation
(D) Chemotaxonomy

206. Which is NOT a characteristic of Liliaceae?
(A) Trimerous flowers
(B) Inferior ovary with parietal placentation
(C) Tepals
(D) Parallel venation

207. DNA barcoding is a:
(A) Histological technique
(B) Serological technique
(C) Palynological technique
(D) Molecular technique

208. Consider Assertion and Reason.
Assertion (A): Apiaceae is a source of spices.
Reason (R): They are rich in aromatic essential oils.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

209. In a caryopsis fruit:
(A) Pericarp is stony.
(B) Seed is attached at one point.
(C) Pericarp is fused to the testa.
(D) Pericarp is winged.

210. Which statement incorrectly describes the androecium?
(A) In Poaceae, stamens are numerous and spiral.
(B) In Asteraceae, stamens are syngenesious.
(C) In Brassicaceae, stamens are tetradynamous.
(D) In Malvaceae, stamens are monadelphous.

211. Which of the following statements about placentation are correct?
1. Marginal
2. Free-central
3. Basal
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

212. What is a taxonomic key?
(A) A comprehensive list of all plant names currently found within a region.
(B) An analytical tool for identifying unknown items by a sequence of choices.
(C) A sophisticated laboratory device for analyzing complex chemical compounds.
(D) A password required to access a secure online database of plant specimens.

213. Pea tendrils are modified:
(A) Stipules
(B) Axillary buds
(C) Terminal leaflets
(D) Adventitious roots

214. Arrange in ascending order.
1. Genus
2. Family
3. Order
4. Species
(A) 4, 1, 2, 3
(B) 1, 4, 2, 3
(C) 4, 2, 1, 3
(D) 1, 2, 3, 4

215. Cause: Ovules are campylotropous. Effect: Micropyle and chalaza are close. Which is true?
(A) The effect is the definition of the cause.
(B) The cause is a result of the effect.
(C) The cause and effect are unrelated.
(D) The effect is opposite of reality.

216. Consider statements.
Statement I: Amentiferae was considered primitive.
Statement II: Modern evidence shows it is artificial.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

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293. Family providing pea and gram:
(A) Poaceae
(B) Solanaceae
(C) Fabaceae
(D) Malvaceae

294. Which about classification are correct?
1. Natural, 2. Phylogenetic, 3. APG
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

295. Rutaceae importance:
(A) Fruits
(B) Cereals
(C) Timber
(D) Vegetables

296. Difference between herbarium and garden:
(A) Local vs global.
(B) Dead preserved vs living plants.
(C) Research vs recreation.
(D) Phylogenetic vs natural.

297. Two or more whorls of stamens is:
(A) Monadelphous
(B) Epipetalous
(C) Diplostemonous or Polystemonous
(D) Syngenesious

298. Match List I with List II.
List I: (Term)
P. Hypogynous,
Q. Perigynous,
R. Epigynous,
S. Gynobasic
List II: (Definition)
1. Inferior,
2. Superior,
3. Base of ovary,
4. Half-inferior
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-2, R-1, S-3

299. Advanced character:
(A) Spiral stamens.
(B) Apocarpy.
(C) Sympetalous corolla.
(D) Unisexual flowers.

300. Family with capitulum and cypsela:
(A) Ranunculaceae
(B) Malvaceae
(C) Solanaceae
(D) Asteraceae

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255. Fruit splitting into four nutlets is characteristic of:
(A) Poaceae
(B) Apiaceae
(C) Lamiaceae
(D) Rosaceae

256. Which is NOT part of Tubiflorales?
(A) Solanaceae
(B) Cucurbitaceae
(C) Verbenaceae
(D) Acanthaceae

257. Role of lodicules in grass flower:
(A) Attract insects.
(B) Protect fruit.
(C) Secrete nectar.
(D) Force open the flower at anthesis.

258. Match List I with List II.
List I: (Plant)
P. Onion,
Q. Wheat,
R. Sunflower,
S. Cabbage
List II: (Family)
1. Asteraceae,
2. Poaceae,
3. Liliaceae,
4. Brassicaceae
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

259. Dipterocarpaceae wings derived from:
(A) Petals
(B) Bracts
(C) Sepals
(D) Stamens

260. A plant with bilabiate corolla and gynobasic style is in:
(A) Verbenaceae
(B) Solanaceae
(C) Acanthaceae
(D) Lamiaceae

261. Consider the following Assertion and Reason.
Assertion (A): Molecular data has become a primary tool in modern plant systematics.
Reason (R): DNA sequences provide a vast number of characters for phylogenetic analysis and resolve relationships that were previously considered ambiguous.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

262. Which feature is NOT characteristic of Centrospermales?
(A) Betalains.
(B) Gynoecium always apocarpous.
(C) Free-central/basal placentation.
(D) Seeds with perisperm.

263. Phylogeny refers to:
(A) Naming.
(B) Interactions.
(C) Evolutionary history.
(D) Distribution.

264. Which about Malvaceae are correct?
1. Mucilage,
2. Monadelphous,
3. Inferior ovary
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

265. Translator apparatus is feature of:
(A) Orchidaceae
(B) Rubiaceae
(C) Asclepiadaceae
(D) Fabaceae

266. Trimerous flower with petaloid perianth is typical of:
(A) Ranunculaceae
(B) Poaceae
(C) Asteraceae
(D) Liliaceae

267. Objective of GIS in taxonomy:
(A) Chromosome number.
(B) DNA sequence.
(C) Map distribution and analyze spatial patterns.

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9. (C) The fossil record shows a clear and gradual transition from gymnosperms to angiosperms.
The sudden appearance and rapid diversification of flowering plants during the Cretaceous period remain a significant challenge in paleobotany. The fossil record does not provide a seamless, gradual series of intermediate forms between gymnosperms and angiosperms. This abrupt emergence led Charles Darwin to describe the origin of angiosperms as an abominable mystery, as the transitional stages are largely missing or poorly understood.

10. (A) Interbreeding natural populations reproductively isolated from other such groups.
The biological species concept emphasizes reproductive isolation as the primary criterion for defining a species. It posits that a species consists of groups of actually or potentially interbreeding natural populations that are isolated from other such groups. This framework focuses on the gene pool and the ability to produce fertile offspring, rather than relying solely on morphological similarities or differences.

11. (D) 1, 2 and 3
The family Brassicaceae is distinguished by several unique botanical features that are essential for its identification. These include a cruciform corolla consisting of four petals and tetradynamous stamens, where four are long and two are short. Additionally, the fruit is typically a siliqua or silicula, characterized by a persistent central partition called the replum, supporting all three stated characteristics.

12. (B) Confined to a specific and defined geographical area and found nowhere else.
Endemism is a critical concept in biogeography and conservation biology, referring to the ecological state of a species being unique to a defined geographic location. Such organisms are naturally found only in one specific region, such as an island, a mountain range, or a particular forest type. This restricted distribution makes endemic species particularly vulnerable to habitat loss and environmental changes.

13. (C) Solanaceae - Tomato
Accurate identification of plant families involves recognizing their economically important members used in agriculture or medicine. Tomato belongs to the Solanaceae family, which also includes potatoes and peppers. In contrast, chickpeas are part of Fabaceae, sunflowers belong to Asteraceae, and basil is a member of the Lamiaceae family. Matching these correctly is fundamental for applied botanical studies and horticulture.

14. (A) 3, 2, 1, 4
Taxonomic hierarchy organizes biological diversity into a series of nested ranks that reflect varying levels of similarity. In descending order from most inclusive to most specific, the correct sequence among the provided options is Class, followed by Order, then Family, and finally Genus. This systematic arrangement allows scientists to categorize organisms based on shared characteristics and their supposed evolutionary relationships.

15. (A) The effect is a direct consequence of the cause.
In plant development, the transition from a vegetative state to a reproductive state is a highly regulated event. When the shoot apical meristem receives specific physiological signals, it responds by altering its growth pattern. This induction directly causes the meristem to stop producing leaves and begin the formation of floral organs, illustrating a clear cause-and-effect relationship in reproductive biology.

16. (C) Statement I is true but Statement II is false.
A herbarium serves as a vital repository of dried and pressed plant specimens, effectively acting as a permanent record of botanical diversity. While it provides essential data for research and identification, its primary function is not the ex-situ conservation of living plants. Living conservation is typically conducted in botanical gardens or seed banks, rather than through the preservation of dead specimens.

17. (B) Monadelphous stamens - Poaceae
Distinguishing plant families requires identifying their unique morphological traits. A gynobasic style is characteristic of Lamiaceae, and syngenesious stamens define the Asteraceae head. Brassicaceae is known for tetradynamous stamens. However, Poaceae typically features three free stamens with versatile anthers rather than monadelphous ones. Monadelphous

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geographical distributions, and diagnostic keys to assist in identification. Unlike a botanical garden which maintains living plants, a Flora serves as a comprehensive literary reference for understanding and identifying the plant diversity of a particular region or country.

35. (C) An apocarpous gynoecium with numerous free carpels.
The family Rubiaceae is characterized by opposite or whorled leaves with distinctive stipules and a syncarpous gynoecium. The ovary is consistently inferior, typically consisting of two fused carpels. These features, along with an actinomorphic, gamopetalous corolla, are used to identify the family. An apocarpous gynoecium with many free carpels is a primitive trait and is not found in the more advanced Rubiaceae.

36. (D) 1, 2 and 3
The family Apocynaceae is recognized by a combination of distinct vegetative and reproductive traits. Most members produce milky latex when wounded. The flowers show contorted aestivation in the bud, and the gynoecium is unique because the two carpels are free at the ovary level but united above by a single style. All three stated features are diagnostic and help in the family's identification.

37. (C) Single-seeded, dry, indehiscent fruit where the pericarp is fused with the seed coat.
The caryopsis is the specialized fruit type characteristic of the Poaceae family, including major grains like wheat and rice. It is a dry, one-seeded fruit that does not split open at maturity. The defining feature of a caryopsis is the complete fusion of the fruit wall, or pericarp, with the seed coat, making them inseparable. This structure is often called a grain.

38. (B) Members typically have numerous, spirally arranged stamens and an apocarpous gynoecium.
The traditional order Ranales includes families like Ranunculaceae and Magnoliaceae, which exhibit several primitive floral characteristics. These plants typically have flowers with an indefinite number of stamens and carpels arranged spirally on an elongated receptacle. The gynoecium is usually apocarpous, meaning the carpels are free from each other. These features represent an ancestral condition compared to the fusion seen in advanced orders.

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39. (D) Laminar or marginal
Evolutionary morphology considers laminar and marginal placentation to be the most primitive types in angiosperms. In these forms, ovules are attached directly to the surface or the edges of a leaf-like carpel. This condition is observed in several primitive families and is thought to represent the original state before more complex arrangements, such as axile or free-central placentation, evolved through carpel fusion and modification.

40. (A) P-3, Q-4, R-1, S-2
Understanding the economic importance of plant families involves correctly associating them with common crops. Rutaceae includes citrus fruits like sweet orange. Malvaceae is the source of cotton fibers. Brassicaceae contains mustard plants, which are significant for oil and food. Apiaceae includes aromatic herbs and vegetables like fennel. Correctly matching these pairings is essential for recognizing the practical utility of various botanical groups.

41. (C) Placentation is parietal with a false septum called a replum.
The family Solanaceae is characterized by a persistent calyx and a superior, bicarpellary ovary that is placed obliquely in the flower. The fruit is usually a berry or a capsule. However, the placentation in this family is axile, with ovules attached to a swollen central placenta. The presence of a false septum called a replum is actually a diagnostic feature of the Brassicaceae family.

42. (C) Statement I is true but Statement II is false.
Geographic Information Systems are computer-based tools used to store, analyze, and display spatial data. In taxonomy, GIS is invaluable for mapping the distribution of species and identifying areas of high biodiversity for conservation. It is not a biochemical technique for analyzing metabolites; that role is filled by chromatography or spectroscopy. Thus, only the first statement accurately describes the function of GIS.

26. (A) Rosaceae
The presence of a hypanthium is a significant diagnostic feature for many genera within the Rosaceae family. This cup-like or tubular structure is formed by the fusion of the basal portions of the sepals, petals, and stamens. The ovary may be situated at the base of the hypanthium or fused to its walls, leading to variations in perceived ovary position from superior to inferior.

27. (D) It was not published in a recognized scientific journal or qualifying medium.
The International Code of Nomenclature (ICN) stipulates strict requirements for the valid publication of new plant names. One essential rule is that the name and description must be published in a widely accessible, permanent medium, typically a peer-reviewed scientific journal or book. Personal blogs do not meet these criteria for effective publication, as they lack the necessary permanence and formal scientific recognition.

28. (B) P-3, Q-1, R-4, S-2
Characteristic inflorescences are vital for identifying plant families. Apiaceae is known for the umbel, where flower stalks arise from a common point. Asteraceae features the capitulum, or head, mimicking a single flower. Lamiaceae typically possesses the verticillaster, a series of false whorls. Poaceae is distinguished by the spikelet, the fundamental unit of its complex and often wind-pollinated reproductive structures.

29. (C) The ovary is superior, syncarpous, and unilocular.
Members of the Cucurbitaceae family are generally climbing herbs with tendrils and unisexual flowers. A key diagnostic feature is the inferior ovary, which is typically syncarpous and often unilocular with parietal placentation. The fruit produced is usually a pepo, a specialized type of berry with a hard rind. Therefore, the statement claiming the ovary is superior is morphologically incorrect for this family.

30. (A) Both Statement I and Statement II are true.
Molecular taxonomy utilizes data from DNA and proteins to establish evolutionary links between different plant groups. This approach provides a high resolution of relationships that traditional morphology might overlook. Rather than replacing older methods, it serves as a powerful complementary tool. By combining molecular evidence with morphological observations, taxonomists can develop a more robust and accurate understanding of plant diversity and classification.

31. (A) A broad, three-veined, leaf-like structure with microsporangia on its surface.
Evolutionary studies suggests that the modern stamen, with its slender filament and distinct anther, evolved from a more primitive, leaf-like structure. These ancestral stamens, seen in some primitive angiosperms, were broad and had microsporangia embedded on the surface or margins. Over time, the fertile portion became restricted to the apex, and the sterile portion narrowed into a filament for more efficient pollen dispersal.

32. (A) 2, 4, 1, 3
The evolutionary timeline of angiosperms begins with the earlier origin of gymnosperms, from which they eventually diverged. The appearance of early Cretaceous fossils provides the first concrete evidence of flowering plants. This was followed by a rapid radiation and diversification across various habitats. During this process, co-evolution with animal pollinators became a significant factor, driving the development of complex floral structures and strategies.

33. (A) Both A and R are true and R is the correct explanation of A.
In the family Asteraceae, the capitulum inflorescence aggregates many small flowers into a single, compact head. This arrangement often includes specialized ray florets that look like petals, making the entire cluster resemble a large flower. This evolutionary strategy is highly effective because it concentrates reproductive resources and provides a conspicuous signal to pollinators, thereby increasing the likelihood of successful fertilization and seed set.

34. (A) A work containing an account of the plants of a region with identification keys.
A Flora is a specialized taxonomic publication that documents the plant species found within a specific geographical area. It typically includes detailed morphological descriptions,

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other types like lectotypes or neotypes may be selected according to ICN rules.

52. (D) Compound spadix or drooping spike
The inflorescence of Musa, or banana, is a large and complex structure known as a compound spadix. It consists of a fleshy main axis bearing clusters of flowers, each subtended by a large, often colorful bract called a spathe. The entire inflorescence often becomes drooping as it matures. This structure is specialized to accommodate numerous flowers and eventually develop into the familiar bunches of fruit.

53. (C) An elongated floral axis bearing spirally arranged stamens and carpels.
Magnoliaceae is considered one of the most primitive angiosperm families. A key ancestral feature is the presence of an elongated, cone-like floral receptacle. On this axis, numerous stamens and carpels are arranged in a spiral pattern, rather than in distinct whorls. This structure is reminiscent of the gymnosperm cone and reflects the early evolutionary stages of the flower before part reduction and fusion.

54. (A) Both Statement I and Statement II are true.
Placentation types are defined by the location of ovule attachment. In axile placentation, the ovary is divided into multiple chambers or locules, and ovules are attached to a central axis. Parietal placentation occurs in a unilocular ovary where ovules are borne on the inner walls. Both statements accurately describe these common and taxonomically important arrangements of ovules, which help in distinguishing various plant families.

55. (C) P-3, Q-4, R-1, S-2
Traditional botanical orders are often characterized by specific morphological traits. Tubiflorales is defined by a gamopetalous, often tubular corolla. Centrospermales frequently features campylotropous ovules and betalain pigments. Helobiales is primarily composed of aquatic or marsh-dwelling herbs. Ranales represents a group with primitive floral characteristics, such as numerous free parts. Correctly matching these orders with their key traits is essential for understanding historical classification systems.

56. (A) Astrology
Plant systematics is a scientific discipline that integrates data from various biological fields to classify and understand plant relationships. Palynology provides evidence from pollen, cytology from chromosomes, and phytochemistry from secondary metabolites. These fields offer measurable, empirical data used in modern taxonomy. Astrology, which is a pseudoscience based on celestial movements, has no empirical basis or relevance to the scientific study of plant classification or evolutionary biology.

57. (C) Zygomorphic
Floral symmetry is a fundamental character in taxonomy. A zygomorphic flower, also known as bilaterally symmetrical, can be divided into two equal mirror-image halves by only one specific vertical plane. This is in contrast to actinomorphic flowers, which exhibit radial symmetry and can be divided by multiple planes. Zygomorphy is often an evolutionary adaptation to facilitate specialized pollination by specific insects, such as bees or butterflies.

58. (A) Both A and R are true and R is the correct explanation of A.
The family Poaceae, or the grass family, is of unparalleled economic importance to human civilization. It includes the major cereal crops that provide the bulk of the global caloric intake, such as rice, wheat, maize, and barley. Additionally, grasses are essential for livestock forage and provide materials for construction and biofuels. The vital role of these staples confirms the family's standing as the most significant group.

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59. (D) The fruit is always a legume.
The Liliaceae family consists mainly of perennial herbs with bulbs or rhizomes and trimerous flowers featuring six tepals. The gynoecium is typically syncarpous with a superior ovary and axile placentation. While the fruit is usually a capsule or occasionally a berry, it is never a legume. Legumes are the specific and characteristic fruit type of the Fabaceae family, not the monocotyledonous Liliaceae.

60. (B) Inward folding of a megasporophyll along its midrib to enclose the ovules.
The conduplicate carpel theory is a widely accepted explanation for the origin of the

43. (D) Functioning as a major center for the ex-situ conservation of plant diversity.
While botanical gardens often serve as public parks, their primary scientific purpose is the ex-situ conservation of plant species. They maintain documented collections of living plants for research, education, and the preservation of rare or endangered taxa. This active role in protecting genetic diversity distinguishes a scientific botanical garden from a purely ornamental garden or a herbarium, which focuses on preserved specimens.

44. (A) Both A and R are true and R is the correct explanation of A.
Members of the Lamiaceae family, such as mint and lavender, are well-known for their characteristic aromas. This scent is produced by volatile essential oils that are synthesized and stored in specialized epidermal structures called glandular hairs or trichomes. When these hairs are touched or broken, the oils are released, explaining the mechanism behind the fragrant nature of these plants and their wide use.

45. (C) An ament or catkin
The Amentiferae is a historical grouping of families that share a common inflorescence type known as a catkin or ament. These are typically elongated, drooping spikes of small, unisexual, wind-pollinated flowers. Although modern phylogenetics has shown this group to be artificial and polyphyletic, the term remains useful in historical contexts for describing families like Fagaceae and Betulaceae that exhibit this specific reproductive structure.

46. (D) Pollinia
In the family Orchidaceae, as well as in Asclepiadaceae, pollen grains are not dispersed individually. Instead, they are fused together into massulae or waxy structures called pollinia. During pollination, the entire pollinium is transferred as a single unit by an insect or other pollinator. This highly specialized mechanism ensures that a large number of pollen grains are delivered to the stigma simultaneously, facilitating efficient fertilization.

47. (A) Siliqua - Brassicaceae
Identifying the correct fruit type is essential for family recognition. Brassicaceae is characterized by a siliqua, which dehisces along two valves from the base. A pepo is found in Cucurbitaceae, not Solanaceae. Legumes are the hallmark of Fabaceae, while Rosaceae has pome, drupe, or achenes. Poaceae features a caryopsis. Therefore, the siliqua and Brassicaceae pairing is the only correct association among the choices provided.

48. (A) 1 and 2 only
The family Euphorbiaceae is known for the presence of milky latex and the specialized cyathium inflorescence found in the genus Euphorbia. While many members have these traits, the ovary is typically superior and trilocular, with one or two ovules in each chamber, rather than being inferior and unilocular. Thus, the third statement is incorrect, making the first and second statements the only correct features.

49. (B) Numerous, free stamens with versatile anthers.
The Asclepiadaceae family is characterized by highly specialized floral structures, including pollinia, a translator apparatus, and a prominent corona. These features are adapted for complex pollination mechanisms. In this family, the stamens are typically five in number and are fused with the style to form a gynostegium. Having numerous, free stamens with versatile anthers is a trait of families like Poaceae or Liliaceae, not Asclepiadaceae.

50. (A) Gynoecium of two fused carpels with a superior ovary.
In a floral formula, the letter G represents the gynoecium. The number 2 indicates that there are two carpels, and the parentheses surrounding the number signify that these carpels are fused, a condition known as syncarpy. A line placed below the G denotes a superior ovary. If the line were above the G, it would indicate an inferior ovary position within the flower.

51. (C) The specimen or illustration designated by the author as the nomenclatural type.
A holotype is the single physical specimen or illustration designated by the original author at the time of publication as the nomenclatural type of a new species name. It serves as the definitive reference point for the application of that name. If a holotype was not designated or has been lost,

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85. (C) Horticultural trade fairs
Herbaria, botanical gardens, and taxonomic literature like Floras are considered essential scientific resources for plant research and identification. They provide preserved specimens, living collections, and detailed descriptions needed for rigorous taxonomic work. Horticultural trade fairs, while important for the plant industry and public interest, are primarily commercial events and do not serve as formal scientific repositories or primary tools for systematic research and documentation.

86. (B) 1 and 3 only
The class Monocotyledonae is distinguished by several key morphological features. These include flowers with parts in multiples of three, known as trimerous, and leaves with parallel venation. Additionally, monocots typically possess a fibrous root system rather than a taproot system. Therefore, only the first and third characteristics listed are typical of monocots, while a taproot system is characteristic of the class Dicotyledonae or eudicots.

87. (D) Forage crops and timber from trees like rosewood.
Beyond being a major source of pulses and legumes, the Fabaceae family has vast economic importance in other sectors. Many species are grown as high-protein forage crops for livestock, such as clover and alfalfa. Furthermore, several members are large trees that provide valuable, high-quality hardwood timber, with rosewood and teak being notable examples. This versatility makes the family one of the most significant in agriculture and industry.

88. (A) A sympetalous (gamopetalous) corolla, typically forming a tube.
The traditional order Tubiflorales is characterized by its sympetalous flowers, where the petals are fused to form a distinct corolla tube. This group includes families like Solanaceae and Lamiaceae. Other features like an apocarpous gynoecium, catkins, or an inferior ovary are not defining traits of this specific order. The tubular corolla is the primary morphological character used in historical systems to define this large and diverse assemblage.

89. (C) Anatomical (Histological) evidence
Anatomical or histological evidence in taxonomy involves the study of internal structures such as vascular bundles, stomata, and cell types. These features are often stable and provide valuable data for distinguishing between different plant groups when external morphology is insufficient. By examining the arrangement and structure of tissues, taxonomists can gain deeper insights into the relationships and evolutionary adaptations of various plant species and families.

90. (B) P-3, Q-1, R-2, S-4
Correctly identifying the characteristic fruit types for different families is essential for plant systematics. Poaceae is known for the caryopsis, while Asteraceae features the cypsela. Cucurbitaceae typically produces a pepo, and Rosaceae members produce a variety of fruits including drupes and pomes. Matching these correctly allows for accurate family-level identification and reflects the diverse evolutionary strategies for seed protection and dispersal within these groups.

91. (D) Names must be descriptive Latin phrases reflecting characteristics.
The fundamental principles of the ICN emphasize the independence of botanical nomenclature and the use of nomenclatural types to determine names. It also dictates that each taxonomic group can have only one correct name. However, the rule that names must be descriptive Latin phrases reflecting characteristics was a feature of pre-Linnaean polynomial nomenclature and is no longer a requirement under the modern binomial system.

92. (A) Both Statement I and Statement II are true.
The family Rosaceae exhibits significant diversity in floral morphology, particularly in the position of the ovary. It can range from fully superior to fully inferior. This variation is often linked to the presence of a hypanthium, a cup-shaped structure formed by fused floral parts. The degree of fusion between the hypanthium and the ovary determines the final position of the ovary, making both statements accurate descriptions of the family.

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angiosperm gynoecium. It proposes that the carpel evolved from a leaf-like structure, or megasporophyll, that bore ovules along its margins. By folding inward along the midrib and fusing at the edges, this structure enclosed and protected the ovules, eventually forming the modern ovary, style, and receptive stigma surface.

61. (B) 1 and 2 only
Taxonomic hierarchy is structured so that Kingdom is the most inclusive rank, containing the greatest diversity of organisms. As one moves up the hierarchy from species toward kingdom, the number of shared characters decreases because the groups become broader and more diverse. However, a genus is a group of related species, not families. Families are grouped into orders, and orders are grouped into classes.

62. (D) Protein similarity is reflected by precipitation reactions between antigens and antibodies.
Serotaxonomy is a branch of taxonomy that uses serological methods to determine the relationships between different plant taxa. It is based on the principle that the degree of similarity between proteins can be measured by the intensity of precipitation reactions when antigens from one plant are mixed with antibodies produced against another. Higher levels of precipitation indicate closer chemical similarity and, by extension, a closer taxonomic relationship.

63. (A) Pea - Fabaceae
Correctly identifying the families of common plants is basic botanical knowledge. Peas belong to the Fabaceae family, characterized by legumes and zygomorphic flowers. Sunflowers belong to Asteraceae, not Rubiaceae. Tomatoes are members of Solanaceae, not Papaveraceae. Onions are part of the Amaryllidaceae or Liliaceae family, not Araceae. Matching pea with Fabaceae is the only accurate pairing among the options provided for these well-known species.

64. (A) 2, 1, 4, 3
The history of plant classification reflects a progression from artificial to natural and finally to phylogenetic systems. Linnaeus developed his sexual system in the mid-18th century. Bentham and Hooker published their natural system in the 19th century. Engler and Prantl followed with an early phylogenetic arrangement. The APG IV system represents the most modern, DNA-based classification. This chronological order shows the evolving understanding of plant diversity.

65. (B) The cause is a primary driver of the effect.
Geographical isolation is a major factor in the process of speciation. When a population is separated from others by physical barriers, it undergoes independent evolution due to different selective pressures and genetic drift. Over time, this leads to the development of a distinct species. If this new species remains restricted to its place of origin, it becomes endemic, showing that isolation is the primary cause.

66. (C) Statement I is true but Statement II is false.
The family Araceae is easily identified by its characteristic inflorescence, the spadix, which is a fleshy spike covered with small flowers and surrounded by a large bract called a spathe. However, the family consists mostly of herbaceous plants, including many climbers and epiphytes, rather than large temperate trees. While some members can be quite large, their habit and distribution do not match the second statement's description.

67. (C) Amentiferae - Fabaceae
Historical classification grouped families into larger orders based on shared traits. Ranunculaceae belongs to Ranales, and Solanaceae is part of Tubiflorales. Alismataceae is a classic example of the Helobiales. The Amentiferae group includes families with catkin inflorescences, such as Fagaceae and Betulaceae. Fabaceae, which has zygomorphic flowers and legumes, is not part of this catkin-bearing group, making it the incorrect pairing among the provided options.

68. (B) P-3, Q-1, R-4, S-2
Botanical terms precisely describe floral structures. Gamopetalous refers to fused petals, while epipetalous describes stamens that are attached to the petals. Syncarpy indicates that the carpels are fused into a single unit. A hypogynous flower has a superior ovary, with other floral parts attached below it. Understanding these terms is fundamental for accurately reading floral formulas and descriptions used in the scientific classification of flowering plants.

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stamens, where filaments are fused into a single tube, are instead a hallmark of the Malvaceae family.

18. (B) P-2, Q-1, R-4, S-3
Modern plant systematics incorporates diverse lines of evidence for classification. Palynology focuses on the intricate morphology of pollen grains, while cytotaxonomy utilizes chromosome number and structure. Serotaxonomy relies on the specificity of antigen-antibody reactions to assess relationships. Chemotaxonomy involves the study of secondary metabolites and chemical constituents. These specialized techniques provide a comprehensive understanding of plant evolution and taxonomic groupings.

19. (C) Papaver somniferum
Papaver somniferum, commonly known as the opium poppy, is the primary source of opium, a substance rich in medicinal alkaloids like morphine and codeine. While other members of the Papaveraceae family, such as Argemone mexicana, contain latex and have various uses, they do not produce the specific commercial product opium. The extraction process involves scoring the unripe seed capsules to collect the sap.

20. (D) Follow the instructions or go to the couplet number indicated at the end.
A dichotomous key functions as an identification tool by offering a series of choices between two contrasting characters. When a user selects a lead that matches their specimen, the key provides a reference to the next specific couplet or a final determination. Following these directions step-by-step is the standard procedure to navigate through the complex hierarchy and achieve an accurate identification.

21. (A) Both A and R are true and R is the correct explanation of A.
The legume or pod is the defining fruit type for the family Fabaceae. It is anatomically derived from a single carpel with a superior ovary. The fruit is characterized by its ability to dehisce along both the dorsal and ventral sutures at maturity, releasing the seeds. This structural development and dehiscence pattern perfectly explain why the legume is a distinct taxonomic character.

22. (B) The presence of a staminal tube formed by the fusion of numerous stamen filaments.
The family Malvaceae is easily recognized by its distinctive androecium. The filaments of numerous stamens are fused together to form a prominent staminal tube that surrounds the style. This monadelphous condition is a key reproductive feature used in identification. In contrast, the gynoecium is typically syncarpous, the fruit is not a caryopsis, and the flowers are usually bisexual and hypogynous.

23. (D) Arranging taxa to reflect their true evolutionary lineage and phylogeny.
Natural systems of classification, such as the influential work by Bentham and Hooker, group plants based on overall morphological similarities and natural affinities. These systems utilize a wide range of characters, placing significant weight on reproductive structures. However, they were developed before phylogenetic principles were fully integrated into taxonomy, meaning they do not explicitly aim to represent the evolutionary history of taxa.

24. (D) 1, 2 and 3
Phylogenetic classification systems seek to organize organisms based on their evolutionary descent. These systems utilize various types of evidence, including fossil records and morphological data, to reconstruct ancestral relationships. The system proposed by Engler and Prantl represents a significant historical step toward this goal. All three statements correctly describe the objectives and historical development of phylogenetic approaches in modern plant systematics.

25. (C) Modified megasporophyll, i.e., a leaf-like structure that bears ovules.
In the evolutionary history of flowering plants, the carpel is interpreted as a modified leaf that has folded and fused to enclose the ovules. This structure is technically termed a megasporophyll. Its primary role is to protect the developing ovules and provide a receptive surface for pollen. This morphological interpretation is fundamental to understanding the transition from gymnosperms to the protected seeds of angiosperms.

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77. (C) The name published in 1890, because it is the earliest legitimate name.
The Principle of Priority is a fundamental rule of the International Code of Nomenclature. It states that the earliest legitimate name published for a particular taxon is the one that must be used. In this case, the name from 1890 has priority over the name from 1905, regardless of which one is more descriptive or recent. This rule ensures stability and prevents the proliferation of multiple names for the same species.

78. (B) P-4, Q-3, R-2, S-1
Specific floral and vegetative structures are diagnostic for different plant families. A gynostegium is found in Asclepiadaceae, while the cyathium is a unique inflorescence of Euphorbiaceae. The gynobasic style is a hallmark of Lamiaceae. Tetradynamous stamens, featuring four long and two short filaments, are characteristic of the Brassicaceae family. Correctly matching these specialized structures with their respective families is a core skill in plant identification.

79. (D) The fruit is exclusively a legume that splits on two sides.
The Rutaceae family is characterized by leaves with translucent glands containing aromatic oils and a prominent nectariferous disc in the flowers. The fruit types are diverse, including the hesperidium seen in Citrus. However, the fruit is never a legume. Legumes are the specific and characteristic fruit type of the Fabaceae family, which is unrelated to the Rutaceae. This distinction is critical for accurate family-level identification.

80. (A) Both Statement I and Statement II are true.
Natural systems of classification, like that of Bentham and Hooker, group organisms based on overall morphological resemblances. Phylogenetic systems, such as APG IV, prioritize evolutionary ancestry and utilize molecular data to determine relationships. Both statements are true and highlight the fundamental differences in philosophy and methodology between these two major approaches to biological classification. They represent the transition from phenetic to cladistic thinking in systematics.

81. (B) Basal angiosperms, Magnoliids, Monocots, and Eudicots.
The APG IV system classifies flowering plants into several major monophyletic clades based on extensive DNA evidence. These include the basal angiosperms, the magnoliids, the monocots, and the eudicots. This arrangement reflects modern understanding of angiosperm phylogeny, moving away from traditional groups like "Dicots," which were found to be paraphyletic. This system provides a more accurate representation of the evolutionary history and diversification of flowering plants.

82. (B) 2, 1, 4, 3
Floral development begins with induction, where the plant receives signals to flower. This is followed by the formation of organ primordia at the meristem. These primordia then undergo differentiation to develop into specific floral parts like sepals, petals, stamens, and carpels. Finally, anthesis occurs, which is the opening of the flower for pollination. This sequential process ensures the orderly transition from vegetative growth to successful sexual reproduction.

83. (A) Both A and R are true and R is the correct explanation of A.
In the family Cucurbitaceae, plants typically produce separate male and female flowers, a condition known as monoecy or dioecy. This unisexuality prevents self-pollination and forces out-crossing between different flowers, which increases genetic diversity. Since these plants are usually pollinated by insects, the floral structure and separation serve as an adaptation to maximize the efficiency of entomophily and ensure healthy seed production.

84. (D) One or a few ovules attached to the base of a unilocular ovary.
Basal placentation occurs when the ovules are attached to the placenta located at the very base of the ovary. This ovary is typically unilocular, meaning it has a single chamber. This arrangement is common in several advanced families, such as Asteraceae and Poaceae, where often only a single ovule is present. This is a distinct and easily recognizable type of placentation used in botanical classification.

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69. (C) Jaculator (Retinaculum)
In many members of the Acanthaceae family, the seeds are dispersed through an explosive dehiscence of the capsule. This process is facilitated by a specialized, hook-like outgrowth of the seed stalk known as a jaculator or retinaculum. As the fruit dries and tension builds, the jaculator snaps, physically flinging the seeds away from the parent plant. This is a highly effective mechanism for localized seed dispersal.

70. (B) Cut representative portions of the frond and arrange them with detailed notes.
When collecting specimens that exceed standard herbarium sheet dimensions, such as large palm fronds, botanists must follow professional guidelines. The accepted method is to take representative sections that show key characters and mount them across multiple sheets or as a single thoughtfully cut piece. This must be accompanied by detailed notes and measurements of the original plant to ensure all taxonomic information is preserved.

71. (A) Both A and R are true and R is the correct explanation of A.
Orchid seeds are among the smallest in the plant kingdom and contain very little endosperm or food reserves. Because they lack the energy needed for independent germination, they have evolved a compulsory symbiotic relationship with mycorrhizal fungi. The fungus provides the necessary nutrients and carbon to the developing embryo, explaining why orchids are so dependent on their fungal partners for successful establishment and growth.

72. (A) The style is terminal on an unlobed or shallowly lobed ovary.
While Verbenaceae and Lamiaceae both belong to the order Lamiales and share features like opposite leaves, they can be distinguished by their gynoecium. In Lamiaceae, the ovary is deeply four-lobed with a gynobasic style arising from between the lobes. In contrast, Verbenaceae typically has a terminal style attached to the top of an unlobed or only shallowly lobed ovary. This structural difference is a key diagnostic character.

73. (C) They are perfectly stable and do not require revision regardless of new data.
Phylogenetic systems are highly valued because they reflect evolutionary history and provide predictive power. However, they are not static or perfectly stable. As new molecular data and more sophisticated analytical methods become available, our understanding of evolutionary relationships often changes, requiring revisions to the classification. This dynamic nature is a fundamental aspect of the scientific process rather than an inherent merit of the system itself.

74. (A) 1 and 2 only
Dipterocarpaceae are economically and ecologically important resinous trees, especially in the tropical forests of Southeast Asia. Their fruits are typically nut-like and are characterized by large, wing-like structures derived from persistent sepals, which aid in wind dispersal. However, their flowers are not small and zygomorphic in heads; they are usually medium-sized, actinomorphic, and arranged in panicles. Therefore, only the first two statements are correct.

75. (D) The morphology, structure, and distribution of pollen and spores.
Palynology is the scientific study of pollen grains and spores. It examines their intricate wall structures, apertures, and overall morphology, which are often highly specific to different plant taxa. This field provides essential data for plant taxonomy, paleobotany, and even forensic science. By analyzing pollen, scientists can identify plant species, reconstruct past environments, and understand the evolutionary history of various groups of flowering plants.

76. (B) Hemi-parasitic or parasitic nature with haustorial connections.
The order Santales, which includes families like Santalaceae and Loranthaceae, is notable for its many parasitic members. These plants develop specialized structures called haustoria that penetrate the tissues of host plants to absorb water and nutrients. Some are hemi-parasites, possessing chlorophyll for photosynthesis but relying on the host for water, while others are holoparasites that are completely dependent on their hosts for all nutritional needs.

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93. (C) High-Performance Liquid Chromatography (HPLC)
In modern chemotaxonomy, High-Performance Liquid Chromatography is one of the most powerful and widely used analytical techniques. It allows for the precise separation, identification, and quantification of a wide range of secondary metabolites within a plant sample. By comparing these chemical profiles across different taxa, researchers can identify unique markers that reflect evolutionary relationships, providing a high level of resolution that traditional methods cannot achieve.

94. (A) Both A and R are true and R is the correct explanation of A.
The evolution of the stamen shows a clear trend from a broad, leaf-like structure to a more specialized form with a slender filament and a distinct anther. This morphological change is driven by natural selection to improve the efficiency of pollen dispersal. By elevating the anther on a filament, the plant can better expose the pollen to wind or animal pollinators, increasing reproductive success.

95. (A) Preserved plant specimens (fluid or dry) for research and reference.
The botanical section of a natural history museum primarily functions as a repository for preserved plant specimens. These may include dried herbarium sheets or specimens preserved in fluid. These collections provide a permanent and verifiable record of plant diversity and are used extensively for taxonomic research, historical studies, and as a reference for identification. They are not typically used for living conservation or commercial purposes.

96. (B) The anti-cancer alkaloids vincristine and vinblastine.
Catharanthus roseus, also known as the Madagascar periwinkle, is of immense medicinal importance because it contains potent alkaloids. Specifically, vincristine and vinblastine are extracted from this plant and are used worldwide in chemotherapy to treat various types of cancer, including leukemia and Hodgkin's lymphoma. This makes the species a classic example of how plant biodiversity can provide life-saving pharmaceutical compounds through secondary metabolites.

97. (B) Euphorbiaceae - Cyathium inflorescence
Identifying unique family characteristics is fundamental in botany. The cyathium is a highly specialized pseudanthium inflorescence that is a hallmark of many genera within the Euphorbiaceae. Apiaceae is known for the umbel, not monadelphous stamens. Malvaceae typically has a superior ovary, and Musaceae does not have tetradynamous stamens. Therefore, the pairing of Euphorbiaceae with the cyathium is the only correct diagnostic feature among the choices.

98. (C) 2 and 3 only
Bentham and Hooker's system is highly regarded for its practical utility in herbarium organization and plant identification. However, it is not a true phylogenetic system as it was not intended to reflect evolutionary lineages. A major recognized demerit is the placement of Gymnospermae between the Dicotyledons and Monocotyledons. Thus, statements 2 and 3 are correct regarding the merits and demerits of this widely used historical classification system.

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99. (C) A gynoecium that is consistently apocarpous with numerous free carpels.
The order Centrospermales is characterized by several distinct traits, including the presence of betalain pigments, campylotropous ovules, and perisperm in the seeds. The placentation is typically free-central or basal. However, the gynoecium in this group is generally syncarpous, meaning the carpels are fused, rather than being consistently apocarpous. An apocarpous gynoecium with many free carpels is more typical of primitive orders like Ranales.

100. (D) Solanaceae
The combination of five fused petals, five epipetalous stamens, and an obliquely placed superior ovary is a classic diagnostic suite for the Solanaceae family. These features, along with axile placentation and a persistent calyx, are used by taxonomists to identify members such as potatoes, tomatoes, and peppers. Families like Ranunculaceae, Brassicaceae, and Poaceae exhibit different floral symmetries and arrangements that do not match this specific description.

and are part of the androecium, which is distinct from the sterile whorls of the perianth.

151. (C) The hypanthium is adnate to the ovary with parts attached above it.
In an epigynous flower, the ovary is termed inferior because of its structural relationship with the other floral parts. The floral receptacle or hypanthium grows upward and fuses completely with the ovary wall. Consequently, the sepals, petals, and stamens appear to arise from the top of the ovary. This condition is a significant diagnostic character in families such as Asteraceae, Cucurbitaceae, and Apiaceae.

152. (D) Sepals
The characteristic wing-like structures found on the fruits of the Dipterocarpaceae family are not derived from the petals or bracts. Instead, they are formed from the persistent and greatly enlarged sepals of the flower. These wings act as a specialized adaptation for wind dispersal, allowing the relatively heavy seeds to be carried away from the parent tree, facilitating the spread and survival of these important tropical forest species.

153. (C) Solanaceae
Ovary position is a fundamental trait used to differentiate plant families. Asteraceae, Cucurbitaceae, and Rubiaceae are all characterized by having inferior ovaries. In contrast, the Solanaceae family typically possesses a superior ovary, where the floral parts are attached below the base of the ovary. Therefore, if a specimen is found to have an inferior ovary, it cannot belong to the Solanaceae family.

154. (A) Both Statement I and Statement II are true.
Modern molecular phylogenetics has revolutionized our understanding of angiosperm relationships. It has demonstrated that the traditional group "dicots" is paraphyletic and not a single evolutionary lineage. Instead, most former dicots belong to a large, monophyletic group called the Eudicots, characterized by triaperturate pollen. Both statements are true and reflect the foundational changes in classification adopted by the Angiosperm Phylogeny Group.

155. (A) The gynoecium is syncarpous, and the ovary is inferior.
Magnoliaceae is recognized as a primitive angiosperm family. Its flowers are characterized by numerous, spirally arranged floral parts on an elongated receptacle. A key ancestral feature is the superior, apocarpous gynoecium, where the carpels are free and separate. The statement claiming that the gynoecium is syncarpous and the ovary is inferior is incorrect, as those are advanced traits not found in this basal lineage.

156. (B) Provide diagnostic keys and descriptions for accurate identification.
The primary and most significant role of a regional Flora is to serve as a scientific tool for identifying plants within a specific area. It provides detailed morphological descriptions and diagnostic keys that allow botanists to systematically distinguish between different species. While it may contain other information, its essential value lies in providing the authoritative data needed for accurate and verifiable plant identification in research and conservation.

157. (C) Perisperm
Perisperm is a specialized nutritive tissue found in the seeds of certain plant families, such as the Amaranthaceae and Piperaceae. Unlike endosperm, which is derived from the triple fusion of nuclei during fertilization, perisperm originates from the diploid tissue of the nucellus within the ovule. This tissue persists and stores food for the developing embryo, serving as an important diagnostic character in seed anatomy and taxonomy.

158. (D) Carrot and parsnip
The family Apiaceae, also known as Umbelliferae, includes several important root vegetables. Carrots and parsnips are classic examples of this family, where the plant stores nutrients in a fleshy taproot. Other members are widely used as aromatic herbs and spices. In contrast, radishes belong to Brassicaceae, potatoes to Solanaceae, and onions to the Amaryllidaceae family. Knowing these associations is fundamental for understanding economic botany.

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109. (C) It comprises predominantly terrestrial desert plants.
The order Helobiales is characterized by families of aquatic or marsh-dwelling herbs, such as Alismataceae. These plants are often regarded as having primitive features among monocotyledons, including a frequently apocarpous gynoecium. Because they are adapted to wet environments, the statement claiming they are predominantly terrestrial desert plants is incorrect. Their morphology and ecology are fundamentally linked to freshwater or wetland habitats, not arid regions.

110. (A) Reduction in carpel number and increased fusion (syncarpy).
The broad evolutionary trend in the angiosperm gynoecium is characterized by a reduction in the number of carpels and an increase in their fusion into a single syncarpous structure. Syncarpy is considered an advanced trait as it allows for more efficient and centralized pollen reception and seed development. This progression from many free carpels to few fused ones is a key theme in the diversification and advancement of flowering plants.

111. (A) 1 and 2 only
The family Asteraceae is defined by its capitulum inflorescence and syngenesious stamens, where the anthers are fused into a tube. These features are highly successful adaptations for pollination. However, the fruit of Asteraceae is not a fleshy drupe; it is a specialized dry, indehiscent fruit called a cypsela, which often bears a pappus for wind dispersal. Therefore, only the first and second statements are correct.

112. (B) Explicitly forbidden and considered illegitimate.
In botanical nomenclature, a tautonym occurs when the specific epithet exactly repeats the generic name. Under the rules of the International Code of Nomenclature (ICN), tautonyms are explicitly forbidden for plant names and are considered illegitimate. This is a significant difference from zoological nomenclature, where tautonyms are permitted and quite common. Any such botanical name proposed must be rejected in favor of a validly published alternative.

113. (C) Araceae - Spadix
Characteristic inflorescence types are essential for family identification. Araceae is uniquely defined by a spadix, which is a fleshy spike surrounded by a spathe. Apiaceae features the umbel, Lamiaceae has the verticillaster, and Euphorbiaceae typically shows the cyathium. Among the choices, the pairing of Araceae with the spadix is the only correct association. These distinct structures reflect the diverse evolutionary strategies for grouping flowers to attract pollinators.

114. (A) 2, 3, 4, 1
The formal taxonomic process for describing a new species begins with the selection and designation of a holotype specimen. This is followed by a rigorous comparison with known species and the analysis of data. Once the taxonomist reaches a conclusion that the species is new, the final step is the valid and effective publication of the name and description in a recognized scientific medium.

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115. (A) The effect is an adaptive advantage of the causal structure.
In the family Lamiaceae, the bilabiate or two-lipped corolla is a specialized floral structure. This shape serves a clear functional purpose by providing a sturdy landing platform for insect pollinators, particularly bees. This adaptation ensures that the pollinator is correctly positioned to receive or deposit pollen, illustrating how the physical form of the flower directly provides an adaptive advantage for successful reproduction and cross-pollination.

116. (A) Both Statement I and Statement II are true.
The androecium of the Brassicaceae family is uniquely characterized as tetradynamous. This term precisely describes a condition where there are six stamens in total, with four inner stamens having long filaments and two outer stamens having shorter ones. This specific arrangement is a primary diagnostic character used for identifying the family. Both statements are true and correctly define this important botanical feature for classification.

117. (B) Glycine max - High-quality timber
Correctly matching plants with their primary economic products is essential in applied botany.

in taxonomy to ensure that plant descriptions are clear and accurate. This standardized vocabulary allows scientists from different parts of the world and different languages to share and understand botanical information without ambiguity. It provides a universal framework for describing complex morphological features, which is fundamental for reliable identification, classification, and scientific communication.

168. (A) Staminal tube (monadelphous).
A hallmark feature of the Malvaceae family is the monadelphous androecium. This condition occurs when the filaments of the numerous stamens are fused together to form a prominent staminal tube that surrounds the style. This unique structure is a primary diagnostic character used in the identification of the family. It is distinct from the tetradynamous stamens of Brassicaceae or the syngenesious stamens of the Asteraceae family.

169. (C) It is large and colourful to attract insects.
The family Poaceae is adapted for wind pollination (anemophily), and its floral parts are significantly modified. The traditional perianth of sepals and petals is absent or reduced to minute, transparent scales called lodicules. Therefore, the statement claiming the perianth is large and colorful to attract insects is incorrect. Instead, these flowers are inconspicuous, lack nectar, and rely on the wind to carry their abundant, lightweight pollen.

170. (C) Statement I is true but Statement II is false.
Herbaria are essential taxonomic tools that provide a wealth of morphological, geographical, and historical data through their collections of preserved plant specimens. However, botanical gardens are characterized by their collections of living plants maintained for research, conservation, and education. The statement claiming that botanical gardens house dried, preserved specimens is incorrect, as that is the specific function of a herbarium rather than a garden.

171. (D) A specimen selected when all original material of the name is lost.
A neotype is a nomenclatural type designated according to the rules of the ICN. It is a specimen selected to serve as the type for a species name when all of the original material used by the author, including the holotype, is known to be lost or destroyed. Choosing a neotype is a necessary step to provide a permanent physical reference for the name when no original material remains.

172. (B) Lamiaceae
A gynobasic style is a specialized morphological feature where the style arises from the base of the ovary, rather than from its apex. This trait is a characteristic and defining feature of the family Lamiaceae, also known as the mint family. In these plants, the ovary is deeply four-lobed, and the style emerges from the center between these lobes. This distinct arrangement is a key character for family identification.

173. (C) Parietal placentation in an inferior ovary.
In the family Cucurbitaceae, the floral structure is typically characterized by an inferior ovary. The ovules are attached to the inner walls of the ovary, a condition known as parietal placentation. Often, the placentae grow inward and meet in the center, which can make the ovary appear multilocular. This combination of an inferior ovary and parietal placentation is a key diagnostic character for this family of climbing plants.

174. (D) Dipterocarpaceae - Spices
Plant families are often associated with their primary economic products. Poaceae provides cereals, Fabaceae provides pulses, and Rutaceae is the source of Citrus fruits. However, the Dipterocarpaceae family is primarily known for its high-quality timber and resins, rather than being a major source of spices. Spices are more commonly derived from families like Apiaceae, Lamiaceae, or Piperaceae. Therefore, the Dipterocarpaceae and spices pairing is incorrect.

175. (A) It facilitates efficient transfer of pollen through targeted mechanisms.
From an evolutionary perspective, the flower is a highly specialized reproductive structure. Its most significant adaptive advantage is that it facilitates the efficient and often targeted transfer of pollen between plants. By utilizing various attractants like color, scent, and nectar, flowers engage animal pollinators, which ensures more reliable fertilization compared to wind pollination. This has driven the incredible diversification and success of angiosperms across the globe.

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and planning conservation strategies. It allows researchers to visualize complex patterns of plant life across different landscapes and environmental conditions.

126. (B) Stipules, bracts, or axillary shoots
The tendrils in the Cucurbitaceae family are specialized climbing organs that exhibit complex morphological origins. Depending on the species, they may be interpreted as modified stipules, bracts, or even reduced axillary shoots. These structures are sensitive to touch and coil around supports, allowing the plants to climb and reach sunlight. This variation in origin is a notable feature in the comparative anatomy of this climbing family.

127. (D) Plant Systematics
Plant systematics is the branch of biology concerned with naming organisms and understanding their evolutionary relationships. It integrates data from various fields to create classification systems that reflect the history of life. While taxonomy focuses specifically on the rules of naming and identification, systematics encompasses the broader study of diversification and phylogeny. A scientist performing these tasks is directly engaged in the systematic study of plant diversity.

128. (A) Lamiaceae
The combination of a square stem, a bilabiate or two-lipped corolla, and a gynobasic style is a diagnostic suite for the family Lamiaceae, also known as the mint family. These features, along with opposite leaves and the presence of aromatic oils, distinguish it from related families in the order Lamiales. While Verbenaceae or Acanthaceae may share some traits, the gynobasic style is specifically characteristic of Lamiaceae.

129. (C) All three have tetradynamous stamens and siliqua fruit.
The family Fabaceae is divided into three subfamilies with distinct floral characteristics. Papilionoideae features zygomorphic flowers and often diadelphous stamens. Caesalpinioideae has imbricate aestivation, and Mimosoideae has actinomorphic flowers with numerous stamens. However, none of these subfamilies possess tetradynamous stamens or siliqua fruit. Those are diagnostic features of the Brassicaceae family, which is unrelated to the legumes of the Fabaceae family.

130. (A) Both Statement I and Statement II are true.
Cytology provides critical data for plant taxonomy through the study of chromosomes. In many cases, the basic chromosome number is highly stable and serves as a reliable marker for an entire genus. Furthermore, polyploidy, or the doubling of chromosome sets, has been a major driver of plant evolution and speciation. Both statements correctly highlight how cytological evidence helps resolve taxonomic relationships and understand evolutionary mechanisms.

131. (D) It does not group taxa according to their phylogenetic relationships.
The natural system proposed by Bentham and Hooker is widely used for its practical benefits in plant identification and herbarium organization. However, its primary demerit is its lack of a phylogenetic basis. Developed during a time when evolutionary theory was not yet fully integrated into classification, the system groups plants based on overall morphological similarity rather than their shared evolutionary history or true ancestral lineages.

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132. (B) Stamens, style, and stigma
In the family Orchidaceae, the male and female reproductive organs are fused into a single, specialized central structure called the gynostemium or column. This structure is formed by the union of the stamens with the style and stigma. This highly specialized arrangement is a hallmark of orchid flowers and is central to their complex and often very specific pollination mechanisms involving various animal vectors.

133. (C) Pome
An apple is a specialized type of fruit known as a pome, which is characteristic of certain genera in the Rosaceae family. In a pome, the edible fleshy part is actually derived from the swollen floral receptacle or hypanthium that surrounds the true fruit. The true fruit, which contains the seeds, forms the central “core” of the apple. This distinguishes it from other fleshy fruit types like berries or drupes.

101. (C) Androecium
The androecium is the collective term for the male reproductive organs of a flower, consisting of all the stamens. Each stamen typically includes a pollen-bearing anther and a supporting filament. The androecium is one of the four main floral whorls, alongside the calyx, corolla, and gynoecium. Its structure, number of parts, and fusion patterns are critical characters used in the taxonomic classification and identification of flowering plants.

102. (B) Tropical hardwood timber (meranti)
The family Dipterocarpaceae is of immense economic importance as a major source of high-quality tropical hardwood timber. Many species, particularly in the genus Shorea, produce wood known commercially as meranti or balau. These trees are dominant in the rainforests of Southeast Asia and provide durable timber used for construction, furniture, and plywood. Their ecological and industrial significance makes them a central focus of tropical forestry and conservation efforts.

103. (B) The floret is enclosed by two bracts, the lemma and the palea.
The reproductive unit in the Poaceae family is a specialized structure called a floret. Unlike many other flowers, the grass floret is small and adapted for wind pollination. It lacks a traditional perianth and is instead enclosed by two protective, scale-like bracts: the lemma on the outer side and the palea on the inner side. This unique arrangement is a fundamental diagnostic feature of the entire grass family.

104. (A) Both Statement I and Statement II are true.
Embryological characteristics, such as the development of the megaspore, the type of endosperm formation, and the structure of the embryo, provide stable and valuable data for plant taxonomy. These traits are often less prone to convergent evolution than external morphology, making them particularly useful for determining relationships at higher taxonomic levels, such as families and orders. Both statements accurately reflect the importance of embryology in systematics.

105. (B) P-3, Q-4, R-1, S-2
Identifying the families of common economic plants is a basic taxonomic skill. Potato belongs to the Solanaceae, while cotton is a member of the Malvaceae. Lentils are part of the Fabaceae, and the sunflower is the flagship member of the Asteraceae family. Correctly matching these pairings is essential for understanding the botanical foundations of agriculture and the distribution of valuable plant products across various taxonomic groups.

106. (B) A syncarpous gynoecium with a single compound pistil.
Ranunculaceae is known for its primitive floral features, including a predominantly herbaceous habit, a superior ovary, and numerous, spirally arranged stamens. A defining trait of the family is its apocarpous gynoecium, where the carpels are free from one another. A syncarpous gynoecium, characterized by fused carpels forming a single compound pistil, is an advanced trait and is not typical for most members of this family.

107. (D) A sequence of paired, contrasting statements (couplets).
A dichotomous key is a fundamental tool in biological identification. It consists of a series of choices, where each step presents two contrasting morphological statements, known as a couplet. By selecting the statement that best describes their specimen, the user is guided through the key until an identification is reached. This logical, step-by-step approach allows for the systematic and efficient identification of unknown organisms based on observable traits.

108. (A) Both A and R are true and R is the correct explanation of A.
Many members of the order Santales, such as sandalwood and mistletoe, exhibit a parasitic or hemi-parasitic lifestyle. This specialized mode of nutrition is made possible by the development of haustoria, which are modified roots or stems that penetrate the host plant's tissues. These organs allow the parasite to directly absorb water and nutrients from the host, explaining the physiological basis for their parasitic nature.

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through molecular data. This approach emphasizes shared derived characters and common ancestry. Consequently, overall phenetic similarity—which groups organisms based on general resemblance without distinguishing between homologous and analogous traits—is given much less importance than in older, traditional systems. This shift ensures that classifications more accurately reflect the true branching history of plant evolution.

143. (D) The sudden appearance of flowering plants in the fossil record.
Charles Darwin's famous phrase "an abominable mystery" referred specifically to the abrupt emergence and rapid diversification of angiosperms in the fossil record during the Cretaceous period. He found the lack of a clear, gradual series of intermediate fossils between non-flowering and flowering plants to be a major challenge to his theory of gradual evolution. This mystery continues to fascinate and challenge paleobotanists today.

144. (A) Brassicaceae
A plant featuring a cruciform corolla, where four petals are arranged in the shape of a cross, and tetradynamous stamens, with four long and two short filaments, is a definitive member of the Brassicaceae family. These characters are highly stable and diagnostic for the entire group, which includes mustard, cabbage, and radish. This combination of traits is not found in families like Fabaceae or Solanaceae.

145. (C) Cucurbitaceae - Superior
Ovary position is a critical character in plant taxonomy. Ranunculaceae, Lamiaceae, and many other families typically have superior ovaries. Asteraceae is consistently characterized by an inferior ovary. In the family Cucurbitaceae, the ovary is also characteristically inferior, meaning it is situated below the attachment point of the other floral parts. Therefore, stating that Cucurbitaceae has a superior ovary is morphologically incorrect for this family.

146. (A) Both Statement I and Statement II are true.
Verbenaceae and Lamiaceae are closely related families within the order Lamiales. Both typically possess opposite leaves and shared floral features. However, they are fundamentally distinguished by their style and ovary structure. Lamiaceae is characterized by a gynobasic style arising from between the four lobes of the ovary, while Verbenaceae has a terminal style. Both statements are correct and highlight the key similarities and differences.

147. (C) Linnaeus, the author.
In the binomial name Solanum tuberosum L., the abbreviation "L." follows the specific epithet. This represents the author citation, signifying that Carolus Linnaeus was the person who first formally described and named the species. Author citations are an essential part of botanical nomenclature, as they provide a clear historical reference and help distinguish between names that might otherwise be identical but were published by different authors.

148. (D) Fertilization
Parthenocarpy is a biological process where fruit develops without the occurrence of fertilization. In commercial bananas, this results in the production of seedless fruit, which is highly desirable for consumption. While pollination may or may not occur depending on the variety, it is the lack of successful fertilization and subsequent seed development that defines the parthenocarpic state. This process allows for fruit production even in the absence of viable pollen.

149. (A) Cup-shaped involucre enclosing one female and several male flowers.
The cyathium is a highly specialized and unique inflorescence type found in the genus Euphorbia. It consists of a cup-shaped involucre that mimics a single flower. Inside this cup, there is a single central female flower consisting of only a pistil, surrounded by several male flowers, each reduced to a single stamen. This complex arrangement, often with colorful glands, is a classic example of a pseudanthium.

150. (B) Stamens
The perianth is the non-reproductive part of a flower that forms an envelope surrounding the reproductive organs. It typically consists of the calyx (sepals) and the corolla (petals). In cases where these two whorls are not clearly differentiated, the individual parts are called tepals. Stamens are the male reproductive parts

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134. (D) Many members contain calcium oxalate raphides.
The family Araceae is notable for its characteristic spadix inflorescence and its diverse range of growth habits. A significant and common internal feature of many members is the presence of calcium oxalate raphides, which are needle-like crystals stored in specialized cells. These crystals serve as a defense against herbivory by causing intense irritation when the plant tissues are chewed, making them a well-known diagnostic trait.

135. (A) Coronary
Placentation refers to the arrangement of ovules within the ovary, and several distinct types are recognized in angiosperms. Axile, parietal, and free-central are common forms that reflect different evolutionary pathways and levels of carpel fusion. Basal and marginal are also standard types. "Coronary" is not a recognized botanical term for a type of placentation, making it the incorrect choice among the established anatomical descriptions provided.

136. (B) Lectotype
Under the rules of botanical nomenclature, a lectotype is a specimen selected from the original material to serve as the nomenclatural type when no holotype was designated or if the original holotype has been lost or destroyed. The selection of a lectotype must be made carefully to ensure it aligns with the original description and author's intent, providing a stable reference for the application of the name.

137. (B) Amentiferae - Flowers are large and insect-pollinated.
Traditional botanical orders are defined by specific floral traits. Ranales often shows apocarpy, and Tubiflorales is known for gamopetalous corollas. Helobiales members are typically aquatic. However, the order Amentiferae is characterized by the presence of small, inconspicuous, unisexual flowers arranged in catkins. These flowers are primarily adapted for wind pollination (anemophily), rather than being large and insect-pollinated, which is the incorrect characteristic listed.

138. (A) Both Statement I and Statement II are true.
Floral development is a precisely regulated process. Induction is the initial step where the shoot apex receives signals and commits to becoming reproductive. Subsequently, the identity of the floral organs is determined by the specific activity of different classes of genes, as described by the influential ABC model. Both statements accurately describe these fundamental stages and genetic mechanisms that govern the transition to flowering in plants.

139. (C) A specimen selected from original material when a holotype was not designated or is lost.
A lectotype is a specific type of nomenclatural type designated under the ICN. It is a specimen selected from the original material used by the author when no holotype was originally named or if the holotype is no longer available. This process is essential for maintaining the link between a name and a physical specimen, ensuring that the botanical name remains accurately and consistently applied.

140. (D) Mucilage
Many members of the Malvaceae family, including okra and hibiscus, are well-known for their slimy or mucilaginous texture. This characteristic is caused by the presence of specialized mucilage-producing cells and canals throughout the plant tissues. Mucilage is a complex carbohydrate that helps the plant retain water and may also serve as a defense mechanism. This feature is widely used in identification and has significant culinary and medicinal implications.

141. (C) Presence of prominent bracts and bracteoles.
In the family Acanthaceae, the inflorescence is often characterized by the presence of conspicuous and frequently colorful bracts and bracteoles. These structures subtend the flowers and are a significant diagnostic feature for many genera. While the flowers are zygomorphic and the fruits are often specialized capsules, the prominent bracts provide a clear visual marker for identifying members of this family in the field or herbarium.

142. (B) Overall phenetic similarity without assessing homology of characters.
Modern phylogenetic systems like APG IV prioritize evolutionary relationships determined

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159. (C) It is cosmopolitan, including terrestrial, epiphytic, and saprophytic habits.
The Orchidaceae is one of the largest and most diverse families of flowering plants. Its members are found in almost every habitat worldwide, exhibiting a wide range of growth habits. While many tropical species are epiphytes growing on trees, many others are terrestrial herbs found in temperate regions. Some species are even saprophytic, lacking chlorophyll and deriving nutrients from decaying organic matter in a symbiotic relationship.

160. (A) Both Statement I and Statement II are true.
The fusion of stamens provides important taxonomic characters. Monadelphous stamens occur when the filaments are fused into a single tube, as seen in Malvaceae. Syngenesious stamens occur when the anthers are fused together while the filaments remain free, which is a hallmark of the Asteraceae family. Both statements accurately define these terms, which are essential for describing floral morphology and identifying different plant groups.

161. (B) Asclepiadaceae and Orchidaceae
Pollinia are specialized waxy masses of pollen grains that are transferred as a single unit during pollination. this advanced reproductive feature is characteristic of two specific plant families: Asclepiadaceae and Orchidaceae. In both families, this mechanism ensures that a large number of pollen grains are delivered simultaneously to the stigma, facilitating efficient fertilization. This shared trait represents an interesting example of convergent evolution in complex pollination strategies.

162. (A) Gamosepalous - A calyx composed of sepals that are free from one another.
Correct botanical terminology is essential for accurate descriptions. Gamosepalous refers to a calyx where the sepals are fused or united, rather than free. The term for free sepals is polysepalous. The other definitions provided for sessile, pedicellate, and apocarpous are correct. Understanding these terms allows scientists to communicate precisely about floral structures and is fundamental for using taxonomic keys and descriptions.

163. (C) Containing a single seed attached at only one point.
An achene is a small, dry, one-seeded fruit that does not split open at maturity. The defining characteristic of an achene is that while the seed is enclosed by the pericarp, the seed coat is attached to the fruit wall at only a single point. This distinguishes it from a caryopsis, where the seed and pericarp are completely fused. Achenes are common in families like Ranunculaceae.

164. (D) Lamiaceae
A square or quadrangular stem in cross-section is a highly characteristic vegetative feature of the Lamiaceae family. This trait, combined with opposite leaves and a bilabiate corolla, makes the family easily recognizable in the field. While some other plants may occasionally show somewhat angled stems, the distinct and consistent squareness is a hallmark of the mint family and is a key diagnostic character for its identification.

165. (C) They are interpetiolar.
In the family Rubiaceae, a prominent and characteristic feature is the presence of interpetiolar stipules. These are stipules that are located on the stem between the bases of opposite leaves. In some species, they may be fused or even resemble the leaves themselves, creating a whorled appearance. This specific type of stipule is a key diagnostic character used to distinguish Rubiaceae from other families with opposite leaves.

166. (B) Relationship classifications may change as new molecular data is analyzed.
Phylogenetic systems aim to reflect the true evolutionary history of organisms. However, they are based on hypotheses that are subject to change. As more sophisticated molecular techniques and broader sampling of DNA sequences are used, our understanding of ancestral relationships can be refined. This can lead to the reorganization of taxa, which is seen as a challenge because it reduces the immediate stability of names and classifications.

167. (B) Ensure clarity, accuracy, and universal understanding among scientists.
The use of semi-technical language and precisely defined botanical terms is essential

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Oryza sativa is the source of rice grain, and Citrus limon provides acidic fruit and essential oils. Papaver somniferum is the source of opium latex. However, Glycine max, or soybean, is grown primarily for its protein-rich seeds and oil, rather than for timber. Timber is typically obtained from large, long-lived woody trees.

118. (B) P-3, Q-4, R-1, S-2
Modern systematics utilizes evidence from multiple biological levels. Molecular evidence is derived from DNA sequences, while cytological evidence focuses on chromosome number and structure. Palynological evidence is obtained from the morphology of pollen grains, and anatomical evidence involves studying internal structures like stomata. Correctly matching these types of evidence with their sources is fundamental to understanding the integrative nature of modern taxonomic research and species classification.

119. (C) A series of pores opening below the persistent stigma.
The fruit of the poppy genus, Papaver, is a specialized capsule that exhibits a unique method of dehiscence. Instead of splitting along sutures, the seeds are released through a series of small pores that open at the top of the capsule, just below the persistent, disk-shaped stigma. This mechanism allows the seeds to be shaken out gradually by the wind, which is an effective strategy for seed dispersal.

120. (D) The calyx consists of 5 fused sepals and the gynoecium of 5 fused carpels.
In a floral formula, symbols and numbers represent floral parts and their condition. K(5) indicates a calyx of five fused sepals, and C(5) indicates five fused petals. A(∞) shows an indefinite number of stamens. G(5) represents a gynoecium with a superior ovary (implied by lack of a line above) composed of five fused carpels. Understanding these conventions is necessary for interpreting technical descriptions of plant families and species.

121. (A) Both A and R are true and R is the correct explanation of A.
Pollination in the Asclepiadaceae family is highly specialized and relies on a complex mechanism. Instead of individual pollen grains, the pollen is aggregated into waxy masses called pollinia. These pollinia are linked together by a translator apparatus, which attaches to the body of a visiting insect. This ensures that a large quantity of pollen is transferred efficiently as a single unit, explaining the unique reproductive strategy.

122. (B) A trend towards reduction and fusion of floral parts.
A major evolutionary trend in angiosperms is the progression from flowers with many free, spirally arranged parts to flowers with fewer, fused parts arranged in whorls. This reduction and fusion, seen in both the perianth and the reproductive organs, often leads to more specialized and efficient pollination mechanisms. This theme is central to understanding the transition from primitive lineages to highly advanced and specialized families.

123. (D) Major commercial timbers like teak and mahogany.
The Solanaceae family is of significant economic importance, providing major food staples like potatoes and eggplants, psychoactive drugs like atropine, and popular spices like chili peppers. However, this family does not include major commercial timber trees. Teak belongs to the Verbenaceae or Lamiaceae family, and mahogany is part of the Meliaceae. Solanaceae is primarily composed of herbaceous plants, shrubs, and only small trees.

124. (D) 1, 2 and 3
For a new plant name to be validly published under the ICN, several conditions must be met. These include providing a description or diagnosis of the taxon and designating a nomenclatural type specimen. Additionally, the publication must be effective, meaning it is distributed in a permanent and accessible scientific medium. All three requirements are mandatory and work together to ensure scientific clarity and the proper application of botanical names.

125. (C) Geographic Information System
The acronym GIS stands for Geographic Information System. It refers to a computer-based framework used for gathering, managing, and analyzing spatial and geographical data. In the context of taxonomy and biodiversity studies, GIS is a powerful tool for mapping species distributions, identifying critical habitats,

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176. (B) Fabaceae
The description of a cruciform corolla and six stamens (specifically tetradynamous ones) is a definitive characteristic of the Brassicaceae family, which is also known as the Cruciferae or the mustard family. Fabaceae, the legume family, is characterized by zygomorphic or actinomorphic flowers with five petals and typically ten stamens in various arrangements. Therefore, a plant with these specific brassicaceous traits cannot belong to the Fabaceae family.

177. (C) Malvaceae - Zygomorphic
Floral symmetry is a stable character used to distinguish families. Brassicaceae flowers are typically actinomorphic, as are most members of the Malvaceae family, which show radial symmetry. Lamiaceae and the Papilionoideae subfamily of Fabaceae are well-known for their zygomorphic, or bilaterally symmetrical, flowers. Therefore, the pairing of Malvaceae with zygomorphic symmetry is incorrect, as radial symmetry is the standard condition for that family's floral structure.

178. (A) Both Statement I and Statement II are true.
The fruit of the Asteraceae family is known as a cypsela. This is a specialized type of dry, indehiscent, one-seeded fruit that develops from an inferior ovary. It often features a persistent calyx modified into a pappus, which aids in wind dispersal. Both statements correctly describe this characteristic fruit, which is a key diagnostic feature used to identify and classify the vast diversity within the sunflower family.

179. (C) A specimen cited in the protologue that is not the holotype or isotype.
A paratype is a nomenclatural term used in the formal description of a new species. It refers to any specimen cited in the original publication (protologue) that was not designated as the holotype or identified as an isotype. Paratypes provide additional information about the variation within the species and help clarify the author's concept of the taxon, although they are not the primary nomenclatural type.

180. (D) Centrospermales (Caryophyllales)
The presence of betalain pigments is a unique and significant chemical marker for the families within the order Centrospermales, now often referred to as Caryophyllales. These pigments replace the more common anthocyanins found in most other flowering plants. This biochemical trait, along with other morphological features like campylotropous ovules and perisperm in seeds, provides strong evidence for the close relationship and monophyly of the families in this order.

181. (A) Names are determined by nomenclatural types.
A salient and fundamental feature of the ICBN, now ICN, is the type method. This principle dictates that every taxonomic name must be permanently associated with a nomenclatural type, which is usually a physical specimen. This ensures that names are applied consistently even if the boundaries of the taxon are changed. Other options like polynomial names or using common names as priority are not part of the modern code.

182. (B) Flowers are large, brightly colored, and pentamerous.
The Poaceae family is characterized by hollow stems called culms and leaves with a sheath and ligule. The flowers are highly modified for wind pollination, being small, inconspicuous, and lacking a colorful perianth. They are arranged in specialized structures called spikelets. Therefore, the statement claiming that grass flowers are large, brightly colored, and pentamerous is incorrect, as these traits are characteristic of many insect-pollinated dicotyledonous families instead.

183. (C) Intentionally reflects evolutionary history using extensive DNA evidence.
The APG IV system represents a significant advancement over older systems like Bentham and Hooker because it is explicitly phylogenetic. It utilizes vast amounts of molecular data, primarily DNA sequences, to reconstruct the evolutionary history of flowering plants. This approach ensures that the classification reflects true ancestral relationships rather than just morphological similarity. This evolutionary basis provides a more robust and scientifically accurate framework for understanding plant diversity.

184. (D) Asteraceae
An inferior ovary is a characteristic floral feature where the other floral parts are attached above the

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Furthermore, its inflorescence is usually a spike or raceme and is never a true verticillaster, which is a hallmark of the Lamiaceae. All three statements correctly identify the key diagnostic and economic features of this family.

235. (C) Gynostegium
In the family Asclepiadaceae, a highly specialized and unique structure called the gynostegium is formed by the fusion of the stamens with the receptive part of the gynoecium, specifically the stigma disk. This central column is a key part of the complex pollination mechanism of the family. This is distinct from a hypanthium, which involves the fusion of outer floral parts, or a gynobasic style, which is a position of the style.

236. (B) Numerology
Plant taxonomy is a scientific discipline that relies on empirical evidence from diverse biological fields. Phytochemistry, cytology, and molecular biology all provide measurable data used for classification and understanding evolutionary relationships. Numerology, however, is a belief system based on the mystical significance of numbers and has no scientific basis or application in the study of botany or the systematic classification of living organisms. Therefore, it is not a taxonomic technique.

237. (D) Cucurbitaceae
A pepo is a specialized type of berry characterized by a hard, leathery rind and parietal placentation. This fruit type is the hallmark of the Cucurbitaceae family, which includes pumpkins, gourds, cucumbers, and watermelons. It is a distinct morphological adaptation for seed protection and dispersal. Understanding the association of the pepo fruit with the Cucurbitaceae is fundamental for correctly identifying and classifying members of this important family of climbing and trailing plants.

238. (B) P-4, Q-3, R-1, S-2
Correctly matching plant genera with their respective families is a core skill in systematic botany. Catharanthus belongs to the Apocynaceae, while Colocasia is a member of the Araceae. Ricinus is the well-known castor oil plant in the Euphorbiaceae, and Tectona, the source of teak, is part of the Verbenaceae. These associations are essential for understanding the distribution of morphological traits and economically important products across various taxonomic groups of flowering plants.

239. (C) Euphorbiaceae
The combination of milky latex, the specialized cyathium inflorescence, and a three-chambered fruit (regma) is diagnostic of many genera within the family Euphorbiaceae. This suite of characters, particularly the cyathium found in Euphorbia, makes the family highly distinctive. While other families like Apocynaceae or Papaveraceae may have latex, they lack the specific inflorescence and fruit structures that define the Euphorbiaceae, allowing for clear and accurate identification.

240. (D) Poaceae
In the family Poaceae, the fundamental unit of the inflorescence is the spikelet. These spikelets are often aggregated into larger, complex structures such as terminal spikes or panicles. This arrangement is a highly specialized adaptation for wind pollination, allowing the flowers to be effectively exposed to the air for pollen release and capture. This structure is a primary diagnostic character used in the identification and classification of grasses worldwide.

241. (A) Both A and R are true and R is the correct explanation of A.
The Brassicaceae family is considered one of the most easily recognizable plant families due to its highly consistent floral morphology. Its members possess a cruciform corolla consisting of four petals and tetradynamous stamens, where four are long and two are short. These stable characters, combined with a specialized fruit like the siliqua, provide a clear and reliable set of features for identification, making the assertion and its provided reason both accurate.

242. (B) Aromatic essential oils
The leaves of plants in the Rutaceae family are typically characterized by the presence of translucent or pellucid glands. These specialized epidermal structures are responsible for producing and storing volatile essential oils. When the leaves are crushed or brushed, these oils are released, giving the plants their characteristic citrusy or spicy aroma. This feature is a key diagnostic character for identifying

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gynoecium. This specific suite of characters is essential for identifying pea-like flowers within the larger legume family.

193. (C) Coffea arabica - Solanaceae
Correctly associating economically important plants with their families is a fundamental botanical task. Triticum aestivum belongs to Poaceae, Rosa indica to Rosaceae, and Daucus carota to Apiaceae. However, Coffea arabica is a member of the Rubiaceae family, which is characterized by opposite leaves with interpetiolar stipules and an inferior ovary. Stating that coffee belongs to the Solanaceae family is an incorrect pairing of a well-known plant.

194. (D) Statement I is false but Statement II is true.
The evolutionary progression of placentation is a subject of morphological study. While the relationships can be complex, it is generally accepted that axile placentation evolved from a primitive marginal state as carpels fused. Furthermore, free-central placentation is often interpreted as being derived from an axile condition through the dissolution of the septa or partition walls. Therefore, the first statement is incorrect while the second statement represents the accepted evolutionary interpretation.

195. (A) Any duplicate specimen of the holotype.
An isotype is a nomenclatural type defined under the rules of the ICN. It is any duplicate specimen of the holotype that was collected by the same person, at the same place and time, and under the same collection number. Isotypes are very important because they provide additional physical reference material and can serve as a backup if the holotype is lost, ensuring the stable application of the species name.

196. (B) Apiaceae
The umbel is a characteristic inflorescence type where multiple flower stalks, or pedicels, of approximately equal length arise from a single common point on the main axis. This arrangement is the hallmark of the Apiaceae family, which was formerly and descriptively named Umbelliferae. Often, these are compound umbels, where each branch of the main umbel ends in a smaller secondary umbel, creating a flat-topped or rounded flower cluster.

197. (C) Natural systems group by overall similarity; phylogenetic by ancestry.
The fundamental difference between natural and phylogenetic systems lies in their underlying philosophy. Natural systems, such as that of Bentham and Hooker, aim to group organisms based on their overall morphological resemblance and natural affinities. In contrast, phylogenetic systems, such as APG IV, prioritize evolutionary ancestry and common descent, using molecular and morphological data to reconstruct the true tree of life. This shift reflects the move from phenetic to cladistic classification.

198. (D) Rubiaceae
The traditional order Tubiflorales is characterized by plants with gamopetalous corollas that often form a tube and superior ovaries. This group includes families like Solanaceae, Verbenaceae, and Lamiaceae. While the Rubiaceae family also has gamopetalous flowers, it is distinguished by having an inferior ovary and is generally placed in a separate group, such as the Rubiales. Therefore, Rubiaceae does not fit the typical description of the Tubiflorales order.

199. (C) Secondary pollen presentation
In the family Asteraceae, the stamens are syngenesious, meaning their anthers are fused into a tube surrounding the style. As the style grows upward through this tube, it pushes the pollen out of the anther cylinder, making it available on the outer surface or on the style itself for visiting pollinators. This mechanism is known as secondary pollen presentation and is a highly effective evolutionary strategy for ensuring successful cross-pollination.

200. (A) Asteraceae, Fabaceae, and Brassicaceae
Many important commercial vegetable oils are derived from the seeds of specific plant families. Sunflowers belong to the Asteraceae, soybeans are a major crop within the Fabaceae, and rapeseed (the source of canola oil) is a member of the Brassicaceae family. Correctly identifying these family associations is essential for understanding the botanical origins of the world's most significant oilseed crops and their respective agricultural and industrial uses.

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and vanilla, rather than being a source of staple food grains. Therefore, this pairing is incorrect.

218. (A) P-3, Q-4, R-1, S-2
Matching families with their unique morphological features is key to plant identification. Asteraceae is characterized by syngenesious stamens. Lamiaceae is defined by its gynobasic style. Poaceae is recognized by the presence of a ligule at the junction of the leaf sheath and blade. Apiaceae is distinguished by its compound umbel inflorescence. These diagnostic traits are fundamental for correctly identifying and classifying these four major families of flowering plants.

219. (C) Morphine
Opium is the dried latex obtained from the unripe seed capsules of the poppy, Papaver somniferum. It contains a complex mixture of alkaloids with significant pharmacological activity. The most prominent and medically important of these is morphine, which is a powerful analgesic. Other alkaloids like codeine and papaverine are also present. Understanding these chemical constituents is vital for both medicine and economic botany in the study of the Papaveraceae family.

220. (D) Solanaceae
A plant characterized by alternate leaves and a superior ovary that is placed obliquely in the flower is a member of the Solanaceae family. This specific oblique orientation of the carpels is a unique and important diagnostic feature of this family, which includes important plants like potatoes and tomatoes. These traits, combined with axile placentation and a persistent calyx, distinguish it from other related families in the same order.

221. (A) Both A and R are true and R is the correct explanation of A.
The APG IV system and the Bentham and Hooker system often place plant groups differently because they are based on fundamentally different philosophies. APG IV is a modern phylogenetic system that uses molecular data to reflect evolutionary relationships. Bentham and Hooker is a natural system based on overall morphological similarity. Because APG IV prioritizes common ancestry over phenetic resemblance, its classifications provide a more accurate representation of evolutionary history.

222. (B) Flowers are zygomorphic with conspicuous bracts.
The family Acanthaceae is primarily composed of herbs and shrubs, often characterized by zygomorphic or bilaterally symmetrical flowers. A prominent and diagnostic feature of their inflorescence is the presence of conspicuous, often colorful bracts and bracteoles that subtend the flowers. The ovary is superior and the fruit is a capsule, rather than a legume. These features are key for recognizing and identifying members of this diverse family.

223. (C) Earliest validly published name is correct.
The Principle of Priority is a core rule of the International Code of Nomenclature (ICN). it dictates that for any taxonomic group from family to species, the correct name is the earliest legitimate name that was validly published according to the code's requirements. This rule ensures stability in nomenclature by preventing the use of multiple names for the same group and providing a clear procedure for determining the accepted name.

224. (D) 1, 2 and 3
The family Magnoliaceae is recognized by several primitive and distinct diagnostic features. These include woody plants or trees that often have large, conical stipules protecting the buds. The flowers are typically solitary and actinomorphic, featuring numerous stamens and carpels that are arranged spirally on an elongated, cone-like receptacle. All three statements correctly describe the essential morphological characters used to identify this basal lineage of flowering plants.

225. (C) Repository for preserved specimens.
The primary and most significant role of a museum's botanical section is to serve as a repository for preserved plant specimens. These collections, which can include dried herbarium sheets or specimens in preservative fluid, provide a permanent and verifiable record of global plant diversity. They are essential resources for taxonomic research, providing reference material for species identification and documentation of historical distributions, rather than focusing on living cultivation or genetic sequencing.

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is completely and inseparable fused with the seed coat, or testa. This unique structure is often referred to as a grain. This fusion distinguishes it from other dry fruits like achenes, where the seed coat is only attached to the pericarp at a single point.

210. (A) In Poaceae, stamens are numerous and spiral.
Correctly identifying androecium characteristics is vital for family classification. Asteraceae has syngenesious stamens, Brassicaceae has tetradynamous stamens, and Malvaceae features monadelphous stamens. However, in the family Poaceae, the stamens are typically few in number—usually three—and have versatile anthers on long filaments. They are not numerous or spirally arranged, which is a primitive trait found in families like Ranunculaceae rather than the highly specialized grass family.

211. (D) 1, 2 and 3
Placentation describes how ovules are attached within the ovary, and various types are key taxonomic characters. Marginal placentation occurs in single-carpel ovaries like those of legumes. Free-central placentation features ovules on a central column in a unilocular ovary. Basal placentation occurs when ovules are at the ovary base. All three terms correctly identify established and important types of placentation found across different families of flowering plants.

212. (B) An analytical tool for identifying unknown items by a sequence of choices.
A taxonomic key is a systematic analytical tool used by scientists and students to identify unknown organisms. It typically works through a series of logical steps, each offering a choice between contrasting morphological features. By making the correct sequence of choices, the user is narrowed down to the correct identification. This is a fundamental practical tool in botany and zoology for navigating biological diversity and accurately naming specimens.

213. (C) Terminal leaflets
In the pea plant (Pisum sativum), which belongs to the family Fabaceae, the leaves are pinnately compound. To facilitate climbing, the upper or terminal leaflets of these compound leaves are modified into slender, coiled structures called tendrils. These tendrils are sensitive to touch and help the plant secure itself to supports. This specific morphological modification is a classic example of an organ adapting for a specialized function like climbing.

214. (A) 4, 1, 2, 3
The taxonomic hierarchy is a nested system where ranks are arranged from most specific to most inclusive. In ascending order, the sequence starts with Species, which are grouped into a Genus. Related genera are grouped into a Family, and families are further grouped into an Order. This arrangement reflects the increasing level of biological diversity and the decreasing level of shared specific characteristics as one moves up the hierarchy.

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215. (A) The effect is the definition of the cause.
A campylotropous ovule is defined by its specific curved shape. In this type of ovule, the body is bent so that the micropyle and the chalaza are brought close to each other. This anatomical arrangement is a fundamental part of the definition of campylotropy. Therefore, stating that the micropyle and chalaza are close is essentially describing the effect or the defining characteristic of what it means for an ovule to be campylotropous.

216. (A) Both Statement I and Statement II are true.
In historical classification systems, the order Amentiferae was often considered primitive because its members possess simple, unisexual flowers arranged in catkins. However, modern molecular and morphological evidence has shown that this group is artificial and polyphyletic, consisting of families that are not closely related. The simple floral structure is now understood as a specialized adaptation for wind pollination rather than a primitive trait. Both statements accurately reflect this taxonomic shift.

217. (B) Orchidaceae - Cereal grains
Correctly matching plant families with their major economic products is a basic botanical requirement. Rutaceae provides Citrus fruits, Musaceae provides bananas, and Euphorbiaceae is a major source of natural rubber. However, cereal grains such as rice, wheat, and maize are the primary products of the Poaceae family. Orchidaceae is known for ornamental flowers

ovary. This condition is a key diagnostic character for the Asteraceae family, where it develops into a specialized fruit called a cypsela. Solanaceae, Brassicaceae, and Liliaceae are generally characterized by superior ovaries. Identifying the correct ovary position is essential for accurately placing a plant within its correct family during the taxonomic identification process.

185. (A) Asteraceae - Axile
Placentation is the arrangement of ovules within the ovary and is often family-specific. Fabaceae has marginal placentation, Solanaceae has axile, and Brassicaceae features parietal placentation. In the family Asteraceae, however, the placentation is basal, with a single ovule attached at the base of the unilocular, inferior ovary. Therefore, pairing Asteraceae with axile placentation is incorrect and contradicts the fundamental morphological characteristics of that family.

186. (A) Both A and R are true and R is the correct explanation of A.
Members of the Poaceae family are classic examples of plants adapted for anemophily, or wind pollination. Their flowers lack colorful petals and nectar, which would be unnecessary for wind-borne dispersal. Instead, they feature a reduced perianth, versatile anthers that easily release pollen, and large, feathery stigmas designed to capture pollen from the air. Both the assertion and the reason correctly describe these specialized reproductive adaptations.

187. (D) Berry
A hesperidium is a specialized and unique type of berry characteristic of the genus Citrus and other members of the Rutaceae family. It is distinguished by a thick, leathery rind containing aromatic oil glands and a fleshy interior divided into segments. These segments are filled with juice-filled hairs that develop from the ovary wall. This structure is a distinct modification of a berry, adapted for protecting and dispersing seeds.

188. (A) Araceae
A spadix subtended by a prominent spathe is the defining inflorescence type of the family Araceae. The spadix is a fleshy spike bearing many small flowers, and the spathe is a large, often leaf-like or colorful bract that partially encloses it. This unique arrangement is a highly successful adaptation for attracting specific insect pollinators and is a primary character used for the identification of aroids worldwide.

189. (C) It is an integrative science building hypotheses of relationships.
Modern angiosperm systematics is a dynamic and integrative field of study. It does not simply aim for a name but seeks to build and test hypotheses about the evolutionary relationships between different plant groups. By combining data from morphology, molecular biology, and other disciplines, systematists continuously refine our understanding of plant phylogeny. This ongoing process recognizes that our classifications are scientific models that must be updated as new evidence emerges.

190. (A) A sympetalous corolla with fused petals forming a tube.
In the evolution of flowers, certain characters are considered primitive or ancestral. These include having an indefinite number of floral parts, spirally arranged parts, and an apocarpous gynoecium with free carpels. In contrast, a sympetalous corolla, where the petals are fused together, is regarded as a more advanced or derived trait. Fusion and reduction of parts often represent evolutionary specializations for more efficient and specific pollination mechanisms.

191. (D) The precise locality and date of collection.
While a herbarium label contains various types of information, the most critical data for biodiversity and ecological studies are the precise locality and the date of collection. This information allows researchers to map species distributions over time, understand phenology, and track changes in plant populations. Without accurate geographic and temporal data, a specimen loses much of its scientific value for modern research in conservation and environmental science.

192. (B) Papilionoideae
The floral formula K(5), C1+2+(2), A(9)+1, G1 represents the diagnostic features of the Papilionoideae subfamily of Fabaceae. It describes a gamosepalous calyx, a zygomorphic corolla with a standard, two wings, and two fused keel petals (papilionaceous), diadelphous stamens in a 9+1 arrangement, and a monocarpellary

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226. (D) Ovary is superior.
The family Musaceae, which includes the banana, is characterized by several distinctive features. These include a pseudostem formed by overlapping leaf bases, trimerous flowers, and a large, drooping spadix inflorescence. However, a key diagnostic character of the family is that the ovary is inferior, meaning it is located below the attachment point of the perianth and stamens. Therefore, stating that the ovary is superior is morphologically incorrect for this family.

227. (A) Actinomorphic
Floral symmetry is a fundamental diagnostic character in plant taxonomy. A flower that can be divided into two equal, mirror-image halves by any vertical plane passing through the center is described as actinomorphic, or radially symmetrical. This is in contrast to zygomorphic flowers, which have only one such plane of symmetry. Actinomorphy is considered a more primitive floral condition and is found in many diverse families such as Brassicaceae and Rosaceae.

228. (A) P-3, Q-1, R-4, S-2
Matching plant products with their botanical families is essential for understanding economic botany. Cotton is a fiber produced by the Malvaceae family. Coffee is derived from the seeds of the Rubiaceae family. Menthol is a prominent essential oil obtained from the Lamiaceae family. Sal is a valuable timber tree belonging to the Dipterocarpaceae family. Correctly identifying these associations reflects a comprehensive knowledge of the practical and industrial uses of various plant groups.

229. (C) Diverse (pome, drupe, achene).
The family Rosaceae is notable for the high degree of diversity in its fruit types. Depending on the genus and species, the fruit can be a fleshy pome (like an apple), a stony drupe (like a cherry or plum), or a collection of small, dry achenes (like those on a strawberry). This variety reflects the different evolutionary strategies for seed protection and dispersal within this large and cosmopolitan family of flowering plants.

230. (D) Cucurbitaceae
A climbing plant characterized by an inferior ovary and a specialized fruit type called a pepo—which is a berry with a hard rind—strongly suggests it belongs to the Cucurbitaceae family. This family includes pumpkins, cucumbers, and melons, most of which share these diagnostic features along with the presence of tendrils for climbing. These traits clearly distinguish it from other families like Solanaceae or Fabaceae, which have different fruit types.

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231. (C) A is true but R is false.
The order Helobiales is widely regarded as a primitive group among the monocotyledons, often exhibiting ancestral floral characters. However, a defining feature of this order is that the gynoecium is typically apocarpous, meaning the carpels are free and separate from each other. Syncarpy, or the fusion of carpels, is an advanced evolutionary trait. Therefore, while the assertion of its primitivity is true, the reason citing syncarpy is morphologically incorrect.

232. (B) From laminar to filament and anther.
Evolutionary morphology has identified a clear trend in the development of the stamen in angiosperms. The primitive state is a broad, three-veined, leaf-like or laminar structure with microsporangia on its surface. Over time, this evolved into the more specialized and efficient modern form, consisting of a slender filament supporting a distinct, pollen-producing anther. This trend represents an adaptation to maximize the effective dispersal of pollen by wind or animal vectors.

233. (C) Tubular, gamopetalous corolla.
The traditional botanical order Tubiflorales is named for its most characteristic floral feature: a gamopetalous corolla that is typically fused into a distinct tube. This group includes families like Solanaceae, Lamiaceae, and Verbenaceae, where this tubular structure is common. While other parts may show fusion, it is the specifically tubular shape of the united petals that provides the historical and descriptive basis for the naming and grouping of these families.

234. (D) 1, 2 and 3
The family Verbenaceae is characterized by several distinct traits. Unlike the square stems of Lamiaceae, Verbenaceae often has round or quadrangular stems with a terminal style. It is the primary source of high-quality teak timber.

251. (C) A is true but R is false.
While it is true that many members of the order Santales are parasitic or hemi-parasitic, it is incorrect to say that they lack chlorophyll. Many are hemi-parasites, such as mistletoe and sandalwood, which possess green leaves and perform photosynthesis but rely on their host for water and minerals through haustorial connections. Only holoparasites lack chlorophyll entirely. Therefore, the assertion is correct, but the generalized reason provided is scientifically inaccurate.

252. (C) Allows efficient centralized pollen reception.
The evolutionary trend from an apocarpous to a syncarpous gynoecium is considered highly advantageous for plants. By fusing multiple carpels into a single syncarpous structure, the plant creates a centralized pollen reception area with a single stigma and style. This allows a single pollination event to potentially fertilize ovules in all fused carpels, increasing the efficiency of reproduction and allowing for more complex control over seed development and dispersal mechanisms.

253. (B) Serology
Serology, or serotaxonomy, is a technique used in modern plant systematics to determine relationships based on chemical similarities in proteins. This method utilizes the specificity of antigen-antibody reactions, where proteins from one plant are used as antigens to produce antibodies in a test animal. The degree of precipitation that occurs when these are mixed reflects the biochemical similarity between taxa, providing a measurable and objective source of evidence for taxonomic classification.

254. (D) 1, 2 and 3
The family Papaveraceae is characterized by several distinct morphological traits. Most members produce a characteristic latex, which can be milky or colored. The gynoecium is typically syncarpous, formed by the fusion of several carpels, and the placentation is characteristically parietal, with ovules attached to the inner walls of the ovary. All three statements correctly identify these diagnostic features, which are essential for the accurate identification and classification of the poppy family.

255. (C) Lamiaceae
A characteristic fruit type found in the Lamiaceae family is a schizocarp that typically splits into four small, dry, one-seeded units called nutlets. This occurs because the bicarpellary ovary becomes deeply four-lobed as it matures. This distinctive method of fruit development and dispersal, combined with other features like a square stem and a bilabiate corolla, is a key diagnostic character used to identify members of the mint family.

256. (B) Cucurbitaceae
The traditional order Tubiflorales is defined by families with gamopetalous corollas and superior ovaries, such as Solanaceae, Verbenaceae, and Acanthaceae. In contrast, the Cucurbitaceae family is characterized by an inferior ovary and is generally excluded from this order in historical classification systems. While it may have some shared traits, its distinct ovary position and fruit type (pepo) place it in a separate taxonomic group, making it the correct exception.

257. (D) Force open the flower at anthesis.
In the highly modified flowers of the Poaceae family, the perianth is reduced to minute, fleshy scales known as lodicules. These structures play a critical role at the time of anthesis. When the flower is ready to open, the lodicules absorb water and swell, physically forcing the lemma and palea apart. This allows the stamens and stigmas to emerge for wind pollination, making the lodicules essential for successful reproductive function in grasses.

258. (A) P-3, Q-2, R-1, S-4
Correctly identifying the families of common economic plants is a basic requirement in botany. Onions are members of the Liliaceae or Amaryllidaceae family. Wheat is a major cereal grain in the Poaceae family. Sunflowers are the flagship members of the Asteraceae, and cabbage is an important vegetable in the Brassicaceae family. Matching these correctly is fundamental for understanding the taxonomic foundations of agriculture and the global distribution of plant resources.

259. (C) Sepals
The prominent wing-like structures found on the fruits of the Dipterocarpaceae family serve

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the family, which includes the economically important genus Citrus.

243. (C) Precise defined botanical terms.
Semi-technical language in botany refers to the use of a standardized and precisely defined set of technical terms to describe plant morphology. This vocabulary allows botanists to create accurate, concise, and universally understandable descriptions of plant structures. By using terms like "actinomorphic," "syncarpous," or "tetradynamous," scientists can communicate complex biological information across different languages and regions, which is essential for the reliable identification and systematic classification of diverse plant species.

244. (C) 1 and 3 only
The family Rosaceae has a cosmopolitan distribution and is found in almost all parts of the world. A common and significant floral feature is the presence of a hypanthium, a cup-shaped structure formed from fused floral parts. However, the ovary position in this family is highly variable and can range from superior to fully inferior. Therefore, the statement claiming that the ovary is always superior is incorrect, while the other two statements are accurate.

245. (D) Petal
In the orchid flower (Orchidaceae), the perianth is trimerous, consisting of three sepals and three petals. One of the petals, usually the median one, is significantly modified in size, shape, and often color to form a specialized structure called the labellum or lip. The labellum serves as a landing platform and attractant for specific pollinators. This modification is a key diagnostic feature of orchids and is central to their complex pollination mechanisms.

246. (A) Rubiaceae
A plant with opposite leaves, interpetiolar stipules, and an inferior ovary is a characteristic member of the Rubiaceae family. These three features combined are highly diagnostic and are used to distinguish this family from others that might share one or two of these traits. Rubiaceae is a large and diverse family that includes economically important plants like coffee and cinchona, and these morphological characters are essential for its accurate identification.

247. (B) Found only in a particular restricted area.
In the context of biogeography and taxonomy, an endemic species is one that is naturally found only in a specific and defined geographical region and nowhere else in the world. This restricted distribution can apply to an island, a country, a mountain range, or even a single forest. Endemism is a critical factor in conservation planning, as endemic species are often more vulnerable to extinction due to their limited habitat range.

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248. (A) P-3, Q-4, R-1, S-2
Matching families with their characteristic fruit types is essential for systematic botany. Poaceae is characterized by the caryopsis, where the seed and pericarp are fused. Asteraceae features the cypsela, a dry fruit from an inferior ovary. Rutaceae produces the hesperidium, a specialized berry with a leathery rind. Fabaceae is defined by the legume or pod. These pairings represent the fundamental morphological characters used to identify and classify these major plant families.

249. (C) Practical for identification.
One of the primary merits of the Bentham and Hooker system of classification is its immense practical value for plant identification and herbarium organization. Because it is based on clearly observable morphological characters, it remains a favorite for field botanists and for the arrangement of physical specimens in many major herbaria worldwide. While it lacks a modern phylogenetic basis, its logical and systematic approach to describing diversity makes it an enduring practical tool.

250. (D) Solanaceae
Both potato and tomato are members of the Solanaceae family, which is also known as the nightshade family. This economically important group is characterized by plants with alternate leaves, pentamerous flowers, and superior ovaries. Other well-known members include eggplants, peppers, and tobacco. Correctly identifying this family is fundamental for understanding the botanical and agricultural relationships between some of our most common and valuable food and medicinal crops.

201. (B) Morphological Concept
The evolutionary species concept defines a species as a single lineage of ancestor-descendant populations that maintains its identity from other such lineages and has its own evolutionary tendencies and historical fate. This view treats species as dynamic, evolving entities rather than static, unchanging units. This concept is particularly useful in paleontology and systematics as it accounts for the temporal dimension of biological diversity and the process of speciation over time.

202. (A) Placement of Gymnosperms between Dicots and Monocots.
While the Bentham and Hooker system is valued for its practical utility, it has significant taxonomic demerits from a modern perspective. The most prominent error is the placement of the Gymnospermae as a group between the Dicotyledones and the Monocotyledones. This arrangement does not reflect the evolutionary reality that gymnosperms are a more ancient lineage and that dicots and monocots are more closely related to each other as angiosperms.

203. (C) Tepals
In many flowers, particularly among monocotyledons, the perianth is not clearly differentiated into a distinct calyx of sepals and a corolla of petals. In such cases, the individual units of the perianth are referred to as tepals. This term is used to describe the floral envelope when all parts are similar in color, texture, and size. Tepals are a common feature in families such as Liliaceae and Amaryllidaceae.

204. (C) Statement I is true but Statement II is false.
Orchidaceae flowers are highly specialized and characterized by zygomorphic symmetry, where one petal is modified into a distinctive labellum or lip. This structure is an adaptation to attract and position pollinators. However, the ovary in orchids is consistently inferior and syncarpous, meaning it is fused and located below the attachment point of the other floral parts. Therefore, the second statement is incorrect as it describes a superior, apocarpous condition.

205. (C) Reconstructing past vegetation
Palynology, the study of pollen and spores, has significant applications beyond pure taxonomy. Because pollen walls are highly resistant to decay and have species-specific morphology, they can be preserved in sediment for thousands of years. By analyzing these fossil pollen records, scientists can reconstruct the composition of past vegetation and understand ancient climates and environmental changes. This application is fundamental in the fields of paleoecology, paleobotany, and quaternary science.

206. (B) Inferior ovary with parietal placentation
The family Liliaceae is a classic monocot family characterized by trimerous flowers with six tepals and leaves with parallel venation. A key diagnostic feature is the superior ovary with axile placentation, where the ovules are attached to a central axis in a typically three-locular ovary. Therefore, the statement claiming that Liliaceae has an inferior ovary with parietal placentation is incorrect, as those features are not typical for this family.

207. (D) Molecular technique
DNA barcoding is a modern molecular technique used for the rapid and accurate identification of biological species. It involves sequencing a short, standardized region of the genome—the "barcode"—and comparing it to a reference database. In plants, regions of the chloroplast genome are commonly used. This molecular approach provides a powerful tool for identifying specimens, detecting cryptic species, and studying biodiversity when traditional morphological characters are insufficient or unavailable.

208. (A) Both A and R are true and R is the correct explanation of A.
The family Apiaceae, formerly Umbelliferae, is a well-known source of numerous spices and aromatic seeds, such as cumin, coriander, and fennel. This economic importance is directly due to the presence of specialized secretory canals throughout the plant tissues, particularly in the fruit walls. These canals produce and store volatile essential oils that provide the characteristic flavors and aromas, explaining the reason for their widespread culinary use.

209. (C) Pericarp is fused to the testa.
A caryopsis is the specialized fruit type of the grass family, Poaceae. It is a dry, indehiscent, one-seeded fruit where the fruit wall, or pericarp,

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as a specialized adaptation for wind dispersal. These wings are not formed from petals or bracts but are derived from the sepals of the flower, which persist and enlarge significantly as the fruit matures. This morphological feature is a key diagnostic character for identifying this family, which includes many dominant and economically important timber trees in Southeast Asian rainforests.

260. (D) Lamiaceae
A plant with a bilabiate or two-lipped corolla and a gynobasic style is a definitive member of the Lamiaceae family. The gynobasic style, which arises from the base of a deeply four-lobed ovary, is a unique and highly diagnostic feature for this family. These traits, along with a square stem and opposite leaves, clearly distinguish it from related families like Verbenaceae, which typically has a terminal style and a different ovary structure.

261. (A) Both A and R are true and R is the correct explanation of A.
Molecular data, particularly DNA sequencing, has revolutionized modern plant systematics. It provides a vast and objective set of characters that allow taxonomists to reconstruct evolutionary relationships with high precision. This molecular evidence has been instrumental in resolving long-standing taxonomic ambiguities that could not be settled by morphological study alone. Both the assertion and its reason are true, reflecting the fundamental shift toward DNA-based phylogenetic analysis in current scientific practice.

262. (B) Gynoecium always apocarpous.
The order Centrospermales is characterized by several distinct features, including the presence of betalain pigments, seeds with perisperm, and free-central or basal placentation. However, the gynoecium in this group is typically syncarpous, meaning the carpels are fused together, rather than being always apocarpous. An apocarpous gynoecium with many free carpels is a primitive trait typical of other orders like Ranales. Therefore, the statement claiming syncarpy is the exception is incorrect.

263. (C) Evolutionary history.
Phylogeny refers specifically to the evolutionary history and line of descent of a group of organisms. It is a fundamental concept in modern systematics, where the primary goal of classification is to reflect the true branching pattern of evolution. By analyzing molecular and morphological data, scientists can construct phylogenetic trees that illustrate how different species and higher taxa are related through common ancestors, providing a framework for all biological study.

264. (A) 1 and 2 only
The family Malvaceae is distinguished by several key diagnostic features, including the presence of mucilage throughout its tissues and a monadelphous androecium where filaments fuse to form a staminal tube. However, the ovary in this family is typically superior, meaning it is located above the attachment of the other floral parts. Therefore, only the first and second statements are correct, while the third statement regarding an inferior ovary is morphologically incorrect for this family.

265. (C) Asclepiadaceae
A translator apparatus is a highly specialized and unique reproductive structure found in the Asclepiadaceae family. It is a mechanical device that connects the pollinia from adjacent anthers, allowing them to be picked up and transferred as a single unit by an insect pollinator. This complex mechanism, along with the gynostegium and corona, represents an advanced evolutionary strategy for ensuring efficient and specific cross-pollination, which is characteristic of this family's complex floral biology.

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266. (D) Liliaceae
A trimerous flower, where floral parts are in multiples of three, and a petaloid perianth, where the sepals and petals look similar, are characteristic features of the Liliaceae family. This family is a classic representative of the monocotyledons, which typically exhibit these floral traits along with parallel leaf venation. This combination of characters, along with a superior ovary and axile placentation, is key for identifying lilies and their relatives within the monocot group.

267. (C) Map distribution and analyze spatial patterns.
In the field of taxonomy and biodiversity research, the primary objective of using Geographic

299. (C) Sympetalous corolla.

In the evolutionary history of angiosperms, certain floral characters are considered more advanced or derived than others. A sympetalous corolla, where the petals are fused together into a single unit, is regarded as an advanced trait compared to having free petals. This fusion often allows for the development of more complex and specialized floral shapes that facilitate specific pollination mechanisms. Other traits like spiral parts and apocarpy are generally viewed as primitive or ancestral conditions.

300. (D) Asteraceae

A plant family uniquely characterized by having its flowers aggregated into a compact head known as a capitulum and producing a specialized dry, indehiscent fruit called a cypsela is the Asteraceae. This family, which includes sunflowers and daisies, is one of the largest and most successful groups of flowering plants. The combination of these two diagnostic features, often accompanied by syngenesious stamens, makes the family easily recognizable and distinguishes it from all other plant groups.

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275. (C) Fruit is a siliqua.
The family Apocynaceae is recognized by several characteristic features, including the presence of latex, contorted aestivation of the corolla lobes, and carpels that are often free at the ovary but united by their styles. However, the fruit of the Apocynaceae is typically a follicle or a berry, rather than a siliqua. A siliqua is the specialized fruit type characteristic of the Brassicaceae family, making it the incorrect feature for the Apocynaceae family.

276. (D) Calyx
In the family Asteraceae, the calyx is often highly modified into a structure called a pappus. This can consist of a ring of hairs, bristles, or scales located at the top of the inferior ovary. The pappus remains attached to the mature fruit, or cypsela, where it serves as a specialized adaptation for wind dispersal, allowing the seeds to be carried long distances away from the parent plant for successful colonization of new habitats.

277. (C) Cytotaxonomy
Cytotaxonomy is a branch of taxonomy that utilizes information from the study of cells, particularly the number, size, and structure of chromosomes, to classify organisms and determine their relationships. This evidence is often very stable and can help distinguish between species that are morphologically very similar. By analyzing karyotypes, taxonomists can gain valuable insights into the evolutionary history and genetic diversity of various plant groups, complementing data from other scientific fields.

278. (A) P-4, Q-3, R-1, S-2
Floral formulas summarize the key diagnostic characters of plant families. Solanaceae is characterized by a five-lobed calyx and corolla with five stamens. Fabaceae (Papilionoideae) features a specialized 1+2+(2) petal arrangement. Brassicaceae is recognized by its unique K2+2 C4 arrangement. Liliaceae is defined by its petaloid perianth of 3+3 tepals. Correctly matching these formula features with their respective families is essential for the technical identification and classification of flowering plants.

279. (B) Starchy corms/tubers.
The family Araceae is of significant economic and dietary importance because many of its members produce large, starchy underground storage organs known as corms or tubers. These structures, such as those found in taro and elephant foot yam, are a major source of carbohydrates for millions of people, particularly in tropical and subtropical regions. This practical utility makes the family a central focus of agricultural botany and food security in many diverse cultures.

280. (A) Gynobasic style.
While the families Lamiaceae and Verbenaceae share several morphological similarities due to their close relationship within the order Lamiales, they can be reliably distinguished by the position of their style. Lamiaceae is uniquely characterized by a gynobasic style, which arises from the base of a deeply four-lobed ovary. In contrast, Verbenaceae typically has a terminal style that is attached to the top of an unlobed or only shallowly lobed ovary.

281. (A) Both A and R are true and R is the correct explanation of A.
The capitulum inflorescence of the Asteraceae family is considered a highly advanced reproductive strategy. By aggregating many small florets into a single head, the plant creates a large, conspicuous display that effectively attracts various animal pollinators. This concentration of reproductive units increases the efficiency of cross-pollination and maximizes the chances of successful fertilization. Both the assertion of its advancement and the reason citing cross-pollination are correct and explain the family's success.

282. (B) Tissues and internal anatomy.
Histological techniques in taxonomy involve the detailed scientific study of plant tissues and internal anatomy through the use of microscopy. By examining the arrangement and structure of cells, vascular tissues, and other internal features, researchers can find stable characters that help in identifying species and understanding their evolutionary relationships. This internal evidence provides a valuable complement to external morphology and is particularly useful

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deposits like tannins and resins.

28. The collective term for phellogen (cork cambium), phellem (cork), and phelloderm (secondary cortex) is:
(A) Bark
(B) Periderm
(C) Stele
(D) Pericycle

29. Which is the correct sequence of layers in a mature dicot stem showing secondary growth, from the outside to the inside?
I Secondary Phloem
II Periderm
III Secondary Xylem
IV Vascular Cambium
(A) I, II, III, IV
(B) II, IV, I, III
(C) II, I, IV, III
(D) III, IV, I, II

30. Anomalous secondary growth, where successive rings of cambium are formed, is observed in the stem of:
(A) Triticum
(B) Dracaena
(C) Helianthus
(D) Boerhaavia

31. In the stem of Dracaena, a monocot, secondary growth occurs due to the activity of:
(A) A cambium that originates in the ground tissue outside the vascular bundles.
(B) A normal vascular cambium formed from the pericycle.
(C) The intrafascicular cambium only.
(D) The fascicular and interfascicular cambium.

32. What is a primary anomalous structure in a plant stem?
(A) The formation of included phloem during secondary growth.
(B) Scattered vascular bundles as seen in a monocot stem.
(C) The development of cork cambium from the cortex.
(D) The presence of annual rings in the wood.

33. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): In some stems, vascular bundles are arranged in two rings, as seen in Strychnos.
Reason (R): This arrangement, which includes medullary and cortical bundles, is a type of primary anomalous structure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

34. A leaf develops from which part of the shoot apical meristem?
(A) The peripheral zone as a leaf primordium
(B) The central zone
(C) The rib meristem
(D) The quiescent center of the shoot

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35. Match the items in List I with the items in List II and select the correct option.
List I: (Type of Phyllotaxy)
P. Alternate
Q. Opposite
R. Whorled
List II: (Arrangement)
1. More than two leaves arise at a node.
2. A single leaf arises at each node.
3. A pair of leaves arise at each node.
(A) P-1, Q-2, R-3
(B) P-2, Q-1, R-3
(C) P-3, Q-1, R-2
(D) P-2, Q-3, R-1

36. Which of the following is NOT a form of leaf diversity based on shape?
(A) Lanceolate
(B) Ovate
(C) Linear
(D) Reticulate

37. A dorsiventral leaf is characteristic of most:
(A) Monocots
(B) Gymnosperms
(C) Dicots
(D) Pteridophytes

38. Identify the incorrect statement regarding the anatomy of a dicot leaf.
(A) Stomata are generally more numerous on the lower (abaxial) epidermis.

291. (A) Both A and R are true and R is the correct explanation of A.
The fruits of the Dipterocarpaceae family are specifically adapted for wind dispersal. They are typically small, nut-like structures that are surrounded by several greatly enlarged, persistent sepals that function as wings. These wings create lift and allow the wind to carry the seeds away from the parent tree, increasing the chances of colonization in new areas. Both the assertion of wind dispersal and the description of the winged sepals are true and correctly explain each other.

292. (B) Central column in unilocular ovary.
Free-central placentation is a specialized arrangement where the ovules are attached to a free-standing central column within the ovary. This type of placentation is characteristically found in a unilocular ovary, where there are no septa or partitions dividing the chamber. It is thought to have evolved from an axile condition through the loss of the partition walls. This arrangement is a key diagnostic character for several plant families, including the Caryophyllaceae and Primulaceae.

293. (C) Fabaceae
The family Fabaceae, also known as the Leguminosae, is the primary source of many of the world's most important pulses and legumes, including peas, grams, beans, and lentils. These plants are characterized by their zygomorphic flowers and their fruit, which is a legume or pod. In addition to being a vital source of protein for humans, many members of this family are important for nitrogen fixation, which improves soil fertility in agricultural systems.

294. (D) 1, 2 and 3
Plant classification has evolved through different stages, including natural systems based on overall similarity and phylogenetic systems based on evolutionary ancestry. The modern APG system is a prominent example of a phylogenetic approach that utilizes extensive DNA evidence. All three statements correctly identify these key concepts and stages in the history of plant systematics, reflecting the shift from phenetic grouping to a more accurate representation of the evolutionary history of flowering plants.

295. (A) Fruits
The family Rutaceae is of immense global economic importance, primarily as the source of a wide variety of edible and highly nutritious fruits. This family includes the genus Citrus, which encompasses oranges, lemons, limes, and grapefruits, as well as other fruits like the bael and wood apple. These fruits are valued for their high vitamin C content and aromatic oils. Understanding this family's role is essential for recognizing its significant contribution to agriculture and human diet.

296. (B) Dead preserved vs living plants.
The fundamental difference between a herbarium and a botanical garden lies in the nature of the plant material they maintain. A herbarium is a repository of dead, pressed, and dried plant specimens that serve as a permanent record for research and identification. In contrast, a botanical garden is a scientific institution that maintains collections of living plants for the purposes of research, conservation, education, and public display. Both are essential, but distinct, tools for systematic botany.

297. (C) Diplostemonous or Polystemonous
In floral morphology, the arrangement and number of stamens can vary significantly. When a flower has two whorls of stamens, with the outer whorl alternating with the petals, it is described as diplostemonous. If there are many whorls or an indefinite number of stamens, the term polystemonous is used. These terms are used to describe the complexity of the androecium and provide important characters for the taxonomic classification and identification of various flowering plant families.

298. (A) P-2, Q-4, R-1, S-3
Precise botanical terms describe the position of the ovary relative to other floral parts. Hypogynous refers to a superior ovary, while epigynous describes an inferior ovary. Perigynous indicates a half-inferior position where parts arise from a cup-shaped structure. Gynobasic describes a style that arises from the base of the ovary. Correctly matching these terms with their definitions is fundamental for accurately interpreting technical plant descriptions and using taxonomic keys for reliable species identification.

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when comparing closely related or cryptic plant taxa.

283. (C) Ranunculaceae
Monocotyledons are a major group of flowering plants that include families such as Poaceae, Liliaceae, and Orchidaceae, characterized by having a single cotyledon in their seeds. In contrast, the family Ranunculaceae is a member of the eudicots, or dicotyledons, which typically possess two cotyledons, reticulate leaf venation, and floral parts in multiples of four or five. Therefore, Ranunculaceae does not belong to the monocot group, making it the correct exception among the provided choices.

284. (D) 1, 2 and 3
The carpel is fundamentally a fertile, leaf-like structure, or megasporophyll, that bears ovules. During evolution, it became folded and fused along its margins to enclose and protect these ovules, eventually forming the modern ovary. This enclosed structure is the defining feature of angiosperms and is the precursor to the fruit that develops after fertilization. All three statements correctly describe the biological origin and evolutionary significance of the carpel in flowering plants.

285. (A) Specific epithet
In the binomial name Mangifera indica Linn., the word "indica" represents the specific epithet. According to the rules of botanical nomenclature, a species name consists of two parts: the generic name (Mangifera) and the specific epithet. Together, they uniquely identify a particular species within a genus. The abbreviation "Linn." is the author citation, indicating that Linnaeus was the person who first formally described and named the species.

286. (B) Brassicaceae
A replum is a specialized and characteristic botanical feature of the Brassicaceae family. It is a persistent, thin, and often transparent central partition or false septum that divides the ovary into two chambers. When the mature fruit—a siliqua or silicula—dehisces, the two outer valves fall away, leaving the replum behind with the seeds attached to its margins. This structure is a primary diagnostic character for identifying members of the mustard family.

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287. (C) Reference collection.
The primary and most direct use of a herbarium is to serve as a permanent scientific reference collection of preserved plant specimens. It provides an authoritative record of plant diversity, allowing researchers to verify identifications, study morphological variation across different regions, and document the history of botanical exploration. While it supports conservation and chemical studies, its core function is to provide a reliable and accessible physical archive for the systematic study of the plant kingdom.

288. (A) P-3, Q-1, R-4, S-2
Correctly matching plant genera with their respective families is a fundamental skill in systematic botany. Prunus is a member of the Rosaceae, while Coffea belongs to the Rubiaceae. Helianthus, the sunflower genus, is the hallmark of the Asteraceae, and Triticum, which includes wheat, is a primary genus in the Poaceae family. These associations are essential for understanding the distribution of morphological characters and the economic importance of various plant groups within the angiosperms.

289. (C) Amentiferae as most primitive.
While the Engler and Prantl system was an early and influential attempt at a phylogenetic classification, it is now recognized to have significant flaws. A major demerit is its placement of the Amentiferae—families with simple, wind-pollinated flowers in catkins—as the most primitive group of angiosperms. Modern evidence has shown that these simple flowers are actually derived and specialized adaptations, and that primitive angiosperms were more likely to have large, bisexual flowers with many parts.

290. (D) Androecium/gynoecium.
In the family Orchidaceae, the male and female reproductive organs are uniquely fused into a single, specialized central structure called the column or gynostemium. This structure is formed by the union of the stamens (androecium) with the style and stigma (gynoecium). This highly specialized arrangement is a hallmark of orchid flowers and is central to their incredibly diverse and often very specific pollination mechanisms involving various animal vectors for efficient pollen transfer.

CHAPTER 04

Morphogenesis and Organogenesis in Plants

1. What is the defining characteristic of meristematic tissue?
(A) It consists of permanently differentiated cells.
(B) It is composed of actively dividing, undifferentiated cells.
(C) It provides mechanical support to the plant.
(D) It is primarily involved in the transport of water and minerals.

2. Based on position, a meristem located at the base of internodes in plants like grasses is classified as:
(A) Intercalary meristem
(B) Apical meristem
(C) Lateral meristem
(D) Secondary meristem

3. Consider the following statements and select the correct option.
Statement I: The root apical meristem is sub-terminal in position due to the presence of a root cap.
Statement II: The shoot apical meristem is terminal in position and gives rise to leaf primordia.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

4. Which of the following is an example of a primary meristem?
(A) Cork cambium
(B) Vascular cambium in a dicot root
(C) Interfascicular cambium
(D) Intrafascicular cambium

5. Match the items in List I with the items in List II and select the correct option.
List I: (Type of Meristem)
P. Apical Meristem
Q. Intercalary Meristem
R. Lateral Meristem
S. Primary Meristem
List II: (Example/Location)
1. Cork cambium
2. Procambium
3. Root apex
4. Base of mint leaves
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

6. The quiescent center, a region of inactive cells in the root apical meristem, is primarily responsible for:
(A) Rapidly producing new cells for primary and secondary root growth.
(B) Acting as a reservoir of cells to replace damaged meristematic cells.
(C) Absorbing water and essential minerals from the surrounding soil layers.
(D) Storing essential food and carbon reserves for the active root tip.

7. Which of the following statements correctly describes the differentiation of primary tissue in a root?
(A) The epidermis, cortex, and vascular cylinder all differentiate from the same layer of cells.
(B) The protoderm gives rise to the vascular cylinder.
(C) The procambium forms the epidermis and root hairs.
(D) The ground meristem differentiates into the cortex.

8. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): The root cap protects the tender

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apex of the root as it pushes through the soil.
Reason (R): The cells of the root cap are parenchymatous and secrete mucilage to lubricate the root's passage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

9. Identify the incorrect statement regarding the anatomy of a typical dicot root.
(A) The xylem is exarch and typically diarch to tetrarch.
(B) The pericycle is single-layered and gives rise to lateral roots.
(C) A large and well-developed pith is present in the center.
(D) The cortex is extensive and composed of parenchyma cells.

10. In a monocot root, the vascular bundles are typically:
(A) Polyarch and exarch
(B) Diarch and exarch
(C) Tetrarch and endarch
(D) Polyarch and endarch

11. Arrange the following zones of a typical root in the correct sequence from the apex upwards.
I Zone of maturation
II Zone of cell division
III Zone of elongation
IV Root cap
(A) I, II, III, IV
(B) IV, III, II, I
(C) II, IV, I, III
(D) IV, II, III, I

12. The secondary growth in a dicot root is initiated by the activity of:
(A) The pericycle and procambium only.
(B) The vascular cambium and the cork cambium.
(C) The endodermis and the epidermis.
(D) The apical meristem exclusively.

13. What is the origin of the vascular cambium during secondary growth in a dicot root?
(A) It originates entirely from the pericycle.
(B) It originates entirely from the conjunctive tissue.
(C) It is partly from the pericycle and partly from the conjunctive tissue.
(D) It is partly primary and partly secondary in origin.

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14. Consider the following statements regarding root modifications:
I Pneumatophores are positively geotropic roots for respiration.
II Stilt roots in maize grow from the lower nodes to provide support.
III Fleshy tap roots in carrots are modified for food storage.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

15. What is the primary role of velamen tissue found in the epiphytic roots of orchids?
(A) To absorb moisture from the air.
(B) To perform photosynthesis.
(C) To provide mechanical support.
(D) To store food materials.

16. The symbiotic association between fungi and the roots of higher plants is known as:
(A) Lichen
(B) Mycorrhiza
(C) Anabaena
(D) Rhizobium

17. Identify the correct statement about root-microbe interactions.
(A) All bacteria forming associations with roots are pathogenic.
(B) Mycorrhizal fungi increase the surface area for water and phosphate absorption.
(C) Leguminous plants form nodules to house nitrogen-fixing cyanobacteria.
(D) Root nodules are primarily for the storage of starch.

18. The histogen theory for the shoot apical meristem was proposed by:
(A) Hanstein
(B) Schmidt
(C) Nageli

(D) Clowes

19. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): In the Tunica-Corpus theory, the tunica consists of one or more peripheral layers of cells.
Reason (R): The cells of the tunica divide primarily anticlinally, contributing to surface growth.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

20. Which layer of the shoot apical meristem, according to the Tunica-Corpus theory, gives rise to the cortex and vascular tissues?
(A) Tunica
(B) Protoderm
(C) Plerome
(D) Corpus

21. Match the items in List I with the items in List II and select the correct option.
List I: (Shoot Modification)
P. Phylloclade
Q. Cladode
R. Stem Tendril
S. Thorn
List II: (Example)
1. Passiflora
2. Bougainvillea
3. Opuntia
4. Asparagus
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

22. A student observes a transverse section of a stem showing vascular bundles arranged in a ring. This is a characteristic feature of a:
(A) Monocot stem
(B) Dicot stem
(C) Dicot root
(D) Monocot root

23. Which of the following statements incorrectly describes the anatomy of a monocot stem?
(A) Vascular bundles are scattered in the ground tissue.
(B) Vascular bundles are conjoint, collateral, and closed.
(C) A sclerenchymatous bundle sheath surrounds each vascular bundle.
(D) Ground tissue is differentiated into cortex, endodermis, and pericycle.

24. Consider the following statements about the vascular cambium:
I It is a lateral meristem responsible for secondary growth.
II It produces secondary xylem towards the inner side and secondary phloem towards the outer side.
III It is composed of fusiform initials and ray initials.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

25. The activity of the vascular cambium is influenced by physiological and environmental factors, leading to the formation of:
(A) Medullary rays
(B) Pith
(C) Annual or growth rings
(D) Lenticels

26. Spring wood (or early wood) differs from autumn wood (or late wood) in that it:
(A) Has wider vessels and is lighter in color.
(B) Has narrower vessels and tracheids.
(C) Is darker in color and has higher density.
(D) Is formed during winter under unfavorable conditions.

27. Heartwood is distinguished from sapwood because heartwood is:
(A) The outer region of secondary xylem and is physiologically active.
(B) The functional part of secondary xylem involved in water conduction.
(C) Lighter in color and susceptible to microbial attack.
(D) Dark in color, non-functional, and contains

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Information Systems is to map the distribution of plant species and analyze their spatial patterns. GIS allows researchers to integrate botanical data with environmental and geographical information to identify centers of diversity, track species movement over time, and plan effective conservation strategies. It is a powerful tool for visualizing and understanding the ecological and geographic context of plant life.

268. (A) P-3, Q-1, R-4, S-2
Correctly matching traditional botanical orders with their representative families is essential for understanding historical classification systems. Ranales includes families with primitive features like Ranunculaceae. Tubiflorales is characterized by gamopetalous families like Lamiaceae. Amentiferae comprises families with catkins, such as Fagaceae. Helobiales is an order of aquatic monocots like Araceae. These pairings reflect the morphological and ecological basis of early systematic groupings used to categorize the diversity of flowering plants.

269. (C) Apiaceae
A plant family characterized by an umbel inflorescence, a schizocarp fruit that splits into two mericarps, and the presence of aromatic essential oils stored in vittae (canals) is the Apiaceae. This family, formerly known as Umbelliferae, includes many important culinary herbs and vegetables like celery and parsley. These specific morphological and chemical traits are highly diagnostic and make the family easily recognizable for identification in both field and laboratory settings.

270. (A) Brassicaceae
Ovary position is a fundamental character used to distinguish between plant families. Asteraceae, Rubiaceae, and Cucurbitaceae are all characterized by having an inferior ovary, where floral parts are attached above the ovary level. In contrast, the Brassicaceae family typically possesses a superior ovary, where the floral parts are attached below the base of the ovary. Therefore, Brassicaceae is the correct choice as it is not characterized by an inferior ovary.

271. (A) Both A and R are true and R is the correct explanation of A.
The family Poaceae, like most monocotyledons, is characterized by a fibrous root system. This condition arises because the primary root, which develops from the embryo, is short-lived and is soon replaced by numerous adventitious roots that arise from the base of the stem. These roots are roughly equal in size and create a dense mat, providing effective anchorage and nutrient absorption, explaining why this root system is typical for the grass family.

272. (B) Comprehensive treatment of a particular taxon worldwide.
A monograph is a specialized taxonomic publication that provides a comprehensive and exhaustive scientific treatment of a particular taxonomic group, such as a genus or family, on a worldwide basis. It includes all known species, detailed descriptions, diagnostic keys, synonymies, and often information on evolutionary relationships and geography. Unlike a local Flora, a monograph aims to be a definitive and complete reference for the chosen taxon across its entire global range.

273. (D) Fusion with stamen.
The evolutionary origin of the angiosperm carpel is thought to have involved the in-rolling and folding of a leaf-like megasporophyll to enclose and protect the ovules. This was followed by the fusion of the leaf margins and the development of a specialized receptive area called the stigma. While the carpel may later fuse with other floral parts in advanced flowers, its primary evolutionary formation did not involve fusion with the stamen as a foundational step.

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274. (D) 1, 2 and 3
The APG IV system is a modern classification of flowering plants based on rigorous phylogenetic analysis. It primarily utilizes molecular data, such as DNA sequences, to reconstruct ancestral relationships. Because our understanding of these relationships is continually refined with new data and better techniques, the system is less stable than older, morphology-based systems, requiring periodic updates. All three statements correctly describe the nature, methodology, and challenges of this influential classification system.

(B) Vascular bundles are of similar sizes and surrounded by a sclerenchymatous sheath.
(C) The mesophyll is differentiated into palisade and spongy parenchyma.
(D) Bulliform cells are usually absent.

39. The most appropriate description of an isobilateral leaf is:
(A) Mesophyll is not differentiated into palisade and spongy tissue.
(B) Stomata are present on both surfaces in approximately equal numbers.
(C) It is oriented vertically to receive sunlight on both surfaces.
(D) All of the above.

40. Bulliform cells, found in the upper epidermis of many monocot leaves, are primarily involved in:
(A) The rolling and unrolling of the leaf in response to water stress
(B) Gaseous exchange
(C) Photosynthesis
(D) Secretion of enzymes

41. Which adaptation is commonly found in xerophytic leaves to reduce water loss?
(A) Thin cuticle and large intercellular spaces.
(B) Stomata present on the upper epidermis only.
(C) Sunken stomata and a thick cuticle.
(D) Undifferentiated mesophyll with air chambers.

42. In the context of the transition to flowering, what is the role of the floral meristem?
(A) It is a determinate meristem that produces the four whorls of a flower.
(B) It is an indeterminate meristem that continues vegetative growth.
(C) It exclusively produces pollen grains.
(D) It develops directly into a fruit after pollination.

43. The ABC model of floral development in Arabidopsis explains how:
(A) The transition from vegetative to reproductive phase occurs.
(B) Double fertilization takes place.
(C) The embryo and endosperm develop.
(D) The identity of the four floral organs (sepals, petals, stamens, carpels) is specified.

44. According to the ABC model of floral development, the expression of A class genes alone in a whorl specifies the development of:
(A) Petals
(B) Sepals
(C) Stamens
(D) Carpels

45. Consider the following statements about floral development in Arabidopsis:
I The combination of A and B class gene activity specifies petals.
II The combination of B and C class gene activity specifies stamens.
III The activity of C class genes alone specifies carpels.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

46. In an Antirrhinum mutant where B function is lost, the resulting flower would have which arrangement of whorls from outside to inside?
(A) Petal, Petal, Stamen, Stamen
(B) Carpel, Stamen, Stamen, Carpel
(C) Sepal, Petal, Petal, Sepal
(D) Sepal, Sepal, Carpel, Carpel

47. The stamen, the male reproductive organ of a flower, consists of:
(A) The anther and the filament
(B) The stigma, style, and ovary
(C) The ovule and the funicle
(D) The receptacle and the pedicel

48. The anther wall layer that provides nourishment to the developing microspores is the:
(A) Epidermis
(B) Tapetum
(C) Endothecium
(D) Middle layers

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49. Microsporogenesis is the process of formation of:
(A) The male gametophyte from a functional microspore.
(B) Microspore tetrads from a microspore mother cell through meiosis.
(C) The embryo sac from a megaspore mother

cell.
(D) Male gametes from the generative cell.

50. The development of a male gametophyte (pollen grain) involves:
(A) One mitotic division of the microspore nucleus to form a vegetative and a generative cell.
(B) Two meiotic divisions of the microspore nucleus.
(C) The fusion of two microspores.
(D) The enlargement of the tapetal cells to form the exine.

51. The pistil or carpel of a flower is composed of which three parts?
(A) Anther, connective, and filament
(B) Receptacle, pedicel, and sepal
(C) Stigma, style, and ovary
(D) Ovule, funicle, and integument

52. An ovule that is completely inverted, with the micropyle lying close to the funicle, is known as:
(A) Orthotropous
(B) Campylotropous
(C) Amphitropous
(D) Anatropous

53. Megasporogenesis refers to the process where:
(A) The megaspore mother cell undergoes mitosis to form the embryo sac.
(B) The functional megaspore develops into the female gametophyte.
(C) The megaspore mother cell undergoes meiosis to form a linear tetrad of megaspores.
(D) The synergids and egg cell are formed.

54. In a typical angiosperm, what is the fate of the four megaspores formed after meiosis?
(A) All four develop into embryo sacs.
(B) Three degenerate, and one functional megaspore develops into the embryo sac.
(C) Two degenerate, and two develop into a bi-sporic embryo sac.
(D) All four remain together to form a compound embryo sac.

55. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): The most common type of embryo sac development in angiosperms is the Polygonum type.
Reason (R): It is monosporic and develops from a single functional megaspore, resulting in a 7-celled, 8-nucleate structure at maturity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

56. The filiform apparatus, a characteristic feature of synergid cells, functions to:
(A) Guide the entry of the pollen tube into the embryo sac.
(B) Produce nectar to attract pollinators.
(C) Provide nourishment to the egg cell.
(D) Prevent the entry of more than one pollen tube.

57. Pollination by wind is referred to as:
(A) Hydrophily
(B) Entomophily
(C) Anemophily
(D) Ornithophily

58. Which of the following is an adaptation for entomophily (insect pollination)?
(A) Brightly colored petals and the presence of nectaries.
(B) Small, inconspicuous flowers without nectar.
(C) Large, feathery stigmas to trap pollen.
(D) Production of a large quantity of light, non-sticky pollen grains.

59. Self-incompatibility in flowering plants is a mechanism that:
(A) Promotes self-pollination and inbreeding.
(B) Ensures fertilization between different species.
(C) Is controlled by the interaction of the pollen and the synergids.
(D) Prevents the germination of pollen on the stigma of the same flower or plant.

60. Match the items in List I with the items in List II and select the correct option.
List I: (Pollination Agency)
P. Insects
Q. Birds

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R. Water
S. Bats
List II: (Term)
1. Chiropterophily
2. Hydrophily
3. Ornithophily
4. Entomophily
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

61. Double fertilization in angiosperms involves:
(A) The simultaneous fusion of two distinct male gametes with a single egg cell.
(B) The fusion of one male gamete with the egg and the other with a synergid cell.
(C) Fusion of one male gamete with the egg and another with the central cell.
(D) Two separate and independent fertilization events in two different embryo sacs.

62. The product of triple fusion is the:
(A) Zygote
(B) Embryo
(C) Perisperm
(D) Primary Endosperm Nucleus (PEN)

63. What is the ploidy level of the primary endosperm nucleus (PEN) in a typical angiosperm?
(A) Triploid (3n)
(B) Haploid (n)
(C) Diploid (2n)
(D) Tetraploid (4n)

64. In nuclear type of endosperm development:
(A) The first and all subsequent nuclear divisions are followed by immediate wall formation.
(B) The primary endosperm nucleus undergoes repeated mitotic divisions without immediate wall formation.
(C) Cell wall formation occurs only at the chalazal end after first nuclear divisions.
(D) The endosperm is consumed entirely by the embryo before the seed reaches its mature state.

65. Coconut water from a tender coconut represents:
(A) The liquid embryo.
(B) The free-nuclear endosperm.
(C) The degenerated nucellus.
(D) The liquid from the vacuole of the egg cell.

66. Which type of endosperm development is characterized by the first division of the PEN being followed by a transverse wall, creating two chambers where further development occurs?
(A) Helobial type
(B) Nuclear type
(C) Cellular type
(D) Ruminate type

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67. The morphological nature of the endosperm is that it is a:
(A) Pre-fertilization tissue equivalent to the female gametophyte.
(B) Part of the sporophyte belonging to the parent plant.
(C) Post-fertilization tissue formed for nourishing the embryo.
(D) A modified part of the cotyledons.

68. The first division of the zygote in a typical dicot embryo development is:
(A) Equal and vertical
(B) Equal and transverse
(C) Unequal and vertical
(D) Unequal and transverse

69. In the development of a dicot embryo, the heart-shaped stage is followed by the:
(A) Globular stage
(B) Proembryo stage
(C) Torpedo stage
(D) Mature embryo stage

70. Consider the following structures of a dicot embryo:
I Plumule
II Cotyledons
III Radicle
Which of the statements given above are correct?
(A) The plumule develops into the root system.
(B) The radicle develops into the shoot system.
(C) The plumule develops into the shoot and the radicle develops into the root.
(D) The cotyledons develop into the primary leaves and perform photosynthesis indefinitely.

120. The exine of a pollen grain is primarily composed of which highly resistant substance?
(A) Sporopollenin
(B) Cellulose
(C) Pectin
(D) Lignin

121. What is the most common type of ovule found in angiosperms?
(A) Orthotropous
(B) Hemitropous
(C) Anatropous
(D) Circinotropous

122. The development of an embryo sac from a diploid nucellar cell without meiosis is termed:
(A) Apospory
(B) Diplospory
(C) Parthenogenesis
(D) Androgenesis

123. Dichogamy, a mechanism to prevent self-pollination, involves:
(A) The physical separation of anthers and stigma.
(B) The genetic inability of pollen to fertilize the same flower.
(C) The presence of unisexual flowers.
(D) The differential timing of maturation of the anther and stigma.

124. The fusion of one male gamete with the egg cell during double fertilization is known as:
(A) Triple fusion
(B) Syngamy
(C) Conjugation
(D) Plasmogamy

125. Match the items in List I with the items in List II and select the correct option.
List I: (Endosperm Type)
P. Nuclear
Q. Cellular
R. Helobial
List II: (Characteristic Feature)
1. First division is followed by wall formation; subsequent divisions are cellular.
2. Intermediate between nuclear and cellular types.
3. Repeated free nuclear divisions before wall formation.
(A) P-1, Q-2, R-3
(B) P-3, Q-1, R-2
(C) P-2, Q-3, R-1
(D) P-3, Q-2, R-1

126. The embryo in a monocot is characterized by the presence of a large scutellum and protective sheaths called:
(A) Hypocotyl and epicotyl
(B) Integuments and perisperm
(C) Nucellus and endosperm
(D) Coleoptile and coleorhiza

127. Identify the correct pair.
(A) Pome - Apple
(B) Berry - Mango
(C) Drupe - Tomato
(D) Legume - Orange

128. An albuminous seed retains a part of its _____ as it is not completely used up during embryo development.
(A) Nucellus
(B) Endosperm
(C) Ovary wall
(D) Funicle

129. The 'importance of seed' is primarily linked to its role in:
(A) Being the sole method of reproduction in all plants.
(B) Providing a method for perennation, dispersal, and protection of the embryo.
(C) Exclusively providing food for humans.
(D) Contributing to the primary growth of the plant.

130. Consider the following methods of vegetative propagation:
I Cutting: A piece of stem or root is planted.
II Layering: A stem attached to the parent plant is induced to form roots while still attached.
III Grafting: A scion is attached to a stock.
Which of these are artificial methods of vegetative propagation?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

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(A) Sexual reproduction
(B) Parthenogenesis
(C) Apomixis
(D) Asexual reproduction

85. In potato, vegetative propagation occurs through:
(A) Runners
(B) Suckers
(C) Tubers (eyes)
(D) Bulbs

86. Bryophyllum is notable for its ability to propagate vegetatively through:
(A) Roots
(B) Leaf notches
(C) Stems
(D) Floral buds

87. Which of the following is an example of a natural vegetative propagation by stem?
(A) Stolons in strawberry
(B) Corms in Colocasia
(C) Rhizomes in ginger
(D) All of the above

88. Arrange the following events in the life cycle of an angiosperm in chronological order.
I Pollination
II Double Fertilization
III Microsporogenesis
IV Seed Development
(A) III, I, II, IV
(B) I, III, II, IV
(C) II, I, IV, III
(D) III, II, I, IV

89. A quiescent center is a component of which meristem?
(A) Shoot apical meristem
(B) Intercalary meristem
(C) Root apical meristem
(D) Vascular cambium

90. In a dicot root, lateral roots originate from the:
(A) Pericycle
(B) Endodermis
(C) Cortex
(D) Pith

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91. The primary difference between the stele of a dicot root and a monocot root is the:
(A) Presence of endodermis in dicots but not in monocots.
(B) Exarch condition in monocots and endarch in dicots.
(C) Absence of pericycle in monocot roots.
(D) Number of xylem and phloem groups.

92. Haustoria or sucking roots are characteristic modifications found in:
(A) Epiphytic plants
(B) Parasitic plants
(C) Halophytic plants
(D) Hydrophytic plants

93. Consider the following statements and select the correct option.
Statement I: Fusiform initials in the vascular cambium are elongated and give rise to the axial system of the secondary xylem and phloem.
Statement II: Ray initials are isodiametric and give rise to the radial system (vascular rays).
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

94. The bark of a tree includes:
(A) Only the secondary phloem.
(B) Only the periderm.
(C) All tissues outside the vascular cambium.
(D) All tissues outside the secondary xylem.

95. Match the items in List I with the items in List II and select the correct option.
List I: (Anatomical Feature)
P. Polyarch xylem in root
Q. Vascular bundles in a ring in stem
R. Bulliform cells in leaf
S. Sunken stomata in leaf
List II: (Plant Group)
1. Dicot
2. Monocot
3. Xerophyte
4. Monocot
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

71. In a monocot embryo, the single, shield-shaped cotyledon is known as the:
(A) Coleoptile
(B) Coleorhiza
(C) Epiblast
(D) Scutellum

72. The protective sheath covering the radicle in a monocot embryo is called the:
(A) Coleorhiza
(B) Coleoptile
(C) Scutellum
(D) Tigellum

73. A fruit that develops from the ovary along with other floral parts like the thalamus is called a(n):
(A) True fruit
(B) Parthenocarpic fruit
(C) False fruit or pseudocarp
(D) Aggregate fruit

74. The wall of the fruit, which develops from the wall of the ovary, is known as the:
(A) Pericarp
(B) Perisperm
(C) Periderm
(D) Pericycle

75. An aggregate fruit, like a strawberry or raspberry, develops from a(n):
(A) Single ovary of a single flower
(B) Entire inflorescence
(C) Multicarpellary, syncarpous gynoecium
(D) Multicarpellary, apocarpous gynoecium

76. A pineapple is an example of a multiple or composite fruit because it develops from:
(A) A single flower with multiple ovaries
(B) An entire inflorescence
(C) A single flower with a single ovary
(D) The thalamus of a single flower

77. Parthenocarpic fruits are characterized by:
(A) Having a very large number of seeds.
(B) Developing from accessory floral parts.
(C) Being developed without the process of fertilization.
(D) Having an extremely hard pericarp.

78. A drupe is a fleshy fruit in which the:
(A) Entire pericarp is fleshy.
(B) Mesocarp and endocarp are fleshy.
(C) Epicarp and mesocarp are dry.
(D) Endocarp is hard and stony.

79. A seed is a fertilized and matured:
(A) Ovule
(B) Ovary
(C) Embryo sac
(D) Egg cell

80. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): In some seeds, such as black pepper and beet, remnants of the nucellus are persistent.
Reason (R): This persistent nutritive tissue, known as the perisperm, provides additional nourishment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

81. A non-albuminous or exalbuminous seed is one in which:
(A) The endosperm is persistent and stores food.
(B) The endosperm is completely consumed by the developing embryo.
(C) The nucellus persists as a food-storing tissue.
(D) The seed coat is absent.

82. The dormancy of seeds is important because it:
(A) Helps the species to survive through unfavorable conditions.
(B) Ensures immediate germination in all conditions.
(C) Prevents the dispersal of seeds to new habitats.
(D) Is a result of a non-viable embryo.

83. The dispersal of seeds and fruits by wind is facilitated by structures like:
(A) Hooks and barbs
(B) Fleshy, edible parts
(C) Pappus and winged extensions
(D) Buoyant, fibrous coats

84. Vegetative propagation is a form of:

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(A) Develop into the cotyledons.
(B) Push the embryo deep into the endosperm.
(C) Form the radicle and root cap.
(D) Absorb nutrients from the surrounding ovular tissue.

109. Which of the following is an example of a simple dry dehiscent fruit?
(A) Mango
(B) Tomato
(C) Legume (pea pod)
(D) Apple

110. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): Grafting is a common method of vegetative propagation used in horticulture.
Reason (R): It allows the combination of desirable traits from two different plants, such as a strong root system (stock) and high-quality fruit (scion).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. The classification of meristems into protoderm, procambium, and ground meristem is based on:
(A) Function
(B) Position in the plant body
(C) Origin and development
(D) Plane of division

112. Identify the incorrect pair regarding root modifications and their examples.
(A) Fusiform root - Radish
(B) Napiform root - Carrot
(C) Conical root - Carrot
(D) Tuberous root - Sweet Potato

113. The pericycle in a monocot root has a different role compared to a dicot root in that it:
(A) Gives rise to the cork cambium.
(B) Only gives rise to lateral roots.
(C) Stores abundant food material.
(D) Is typically sclerenchymatous and provides mechanical support.

114. A key difference between secondary growth in a dicot stem and a dicot root is:
(A) The origin of the vascular cambium.
(B) The production of secondary xylem and phloem.
(C) The presence of a periderm.
(D) The formation of annual rings.

115. A plant exhibits stems that are flattened and green, performing the function of leaves. These modified stems are known as:
(A) Cladodes
(B) Bulbils
(C) Phylloclades
(D) Thorns

116. "Included phloem" or "interxylary phloem" is a characteristic feature of anomalous secondary growth found in the stems of:
(A) Dracaena
(B) Boerhaavia
(C) Triticum
(D) Leptadenia and Salvadora

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117. Consider the following statements and select the correct option.
Statement I: Isobilateral leaves are common in monocots like grass.
Statement II: Dorsiventral leaves are characteristic of dicots and are oriented horizontally.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

118. The transition from a vegetative apical meristem to a floral meristem is:
(A) Reversible under certain light conditions.
(B) A permanent change marking the end of vegetative growth at that apex.
(C) An indeterminate process.
(D) Initiated by the hormone auxin.

119. A mutation in Antirrhinum that eliminates both B and C class gene function would result in a flower composed of:
(A) Only carpels
(B) Sepals and petals
(C) Stamens and carpels
(D) Only sepals

(B) Anatropous
(C) Amphitropous
(D) Orthotropous

144. A tetrasporic embryo sac (e.g., Peperomia type) develops from:
(A) One megaspore nucleus
(B) All four megaspore nuclei
(C) Two megaspore nuclei
(D) Three megaspore nuclei

145. In hydrophily, where pollination occurs by water, the pollen grains are often protected from wetting by a:
(A) Sporopollenin coat
(B) Mucilaginous covering
(C) Thick cuticle
(D) Callose plug

146. Triple fusion results in a triploid nucleus because it involves the fusion of:
(A) One male gamete (n) and two polar nuclei (n+n).
(B) One male gamete (n) and one egg cell (n).
(C) Two male gametes (n+n) and one polar nucleus (n).
(D) Three haploid nuclei from the pollen tube.

147. A ruminate endosperm is characterized by its:
(A) Smooth and uniform surface.
(B) Completely liquid consistency.
(C) Uneven and irregular surface due to ingrowths of the seed coat.
(D) Presence in all monocot seeds.

148. The part of the embryonal axis between the plumule and the cotyledons in a dicot embryo is called the:
(A) Hypocotyl
(B) Radicle
(C) Suspensor
(D) Epicotyl

149. Identify the fruit type that is a fleshy fruit developing from an inferior ovary, where the edible part is mainly the thalamus.
(A) Drupe
(B) Berry
(C) Pome
(D) Hesperidium

150. The scar on a seed that marks the point of attachment of the funicle is known as the:
(A) Micropyle
(B) Hilum
(C) Chalaza
(D) Raphe

151. Apomixis is a process of seed formation that mimics sexual reproduction but occurs without:
(A) Pollination
(B) Embryo development
(C) Endosperm formation
(D) Meiosis and syngamy

152. A runner is a sub-aerial stem modification for vegetative propagation, characterized by:
(A) A horizontal branch with long internodes that roots at the nodes.
(B) A fleshy, underground horizontal stem.
(C) An arched stem that touches the ground and roots at the tip.
(D) A vertical underground stem with fleshy leaves.

153. A meristem that develops from primary permanent tissue and is responsible for secondary growth is called a:
(A) Promeristem
(B) Primary meristem
(C) Secondary meristem
(D) Intercalary meristem

154. In the root, Casparian strips are suberized thickenings found in the radial and tangential walls of which tissue?
(A) Endodermis
(B) Pericycle
(C) Cortex
(D) Epidermis

155. Match the items in List I with the items in List II and select the correct option.
List I: (Tissue/Region)
P. Heartwood
Q. Sapwood
R. Vascular Cambium
S. Cork Cambium
List II: (Primary Function)
1. Produces periderm
2. Water conduction
3. Mechanical support, non-conductive

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131. Which meristem is responsible for the formation of primary permanent tissues?
(A) Secondary meristem
(B) Lateral meristem
(C) Apical meristem
(D) Cork cambium

132. The 'Histogen Theory' proposes three distinct layers in the apical meristem: dermatogen, periblem, and plerome. These correspond to the development of:
(A) Epidermis, vascular tissue, and cortex respectively.
(B) Cortex, epidermis, and vascular tissue respectively.
(C) Vascular tissue, cortex, and epidermis respectively.
(D) Epidermis, cortex, and vascular tissue respectively.

133. A root system where the primary root is short-lived and is replaced by a large number of roots originating from the base of the stem is called a:
(A) Tap root system
(B) Adventitious root system
(C) Fibrous root system
(D) Haustorial root system

134. In a dicot root, the tissue located between the xylem and phloem bundles is called:
(A) Pith
(B) Conjunctive tissue
(C) Medullary ray
(D) Hypodermis

135. The presence of a vascular cambium between the xylem and phloem makes the vascular bundle:
(A) Closed
(B) Radial
(C) Exarch
(D) Open

136. The functional wood that is lighter in color and actively conducts water is:
(A) Sapwood (alburnum)
(B) Heartwood (duramen)
(C) Early wood only
(D) Late wood only

137. Lenticels are pores in the periderm that facilitate:
(A) Photosynthesis
(B) Water absorption
(C) Gaseous exchange
(D) Guttation

138. A stem that shows vascular bundles where phloem is found on both the outer and inner sides of the xylem is described as:
(A) Bicollateral
(B) Collateral
(C) Radial
(D) Amphivasal

139. In the anatomy of a leaf, what is the primary function of the palisade parenchyma?
(A) Gaseous exchange
(B) Water storage
(C) Mechanical support
(D) Photosynthesis

140. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): In many aquatic plants, the leaves are highly dissected or ribbon-like.
Reason (R): This leaf morphology reduces resistance to water currents and increases the surface area for absorption of nutrients.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

141. The expression of B class genes in combination with C class genes in the ABC model leads to the formation of:
(A) Petals
(B) Carpels
(C) Stamens
(D) Sepals

142. What is the ploidy of a microspore mother cell?
(A) n
(B) 3n
(C) 4n
(D) 2n

143. An ovule with a curved body, but an embryo sac that remains straight, is termed:
(A) Campylotropous

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96. What is the most appropriate term for the arrangement of leaves where a pair of leaves at one node is at a right angle to the next upper or lower pair?
(A) Alternate
(B) Opposite decussate
(C) Opposite superposed
(D) Whorled

97. The presence of Casparian strips in the endodermal cells of the root is a key feature that:
(A) Aids in water storage.
(B) Forces water and solutes to pass through the cell membrane, regulating uptake.
(C) Provides mechanical strength to the cortex.
(D) Is the site of origin for lateral roots.

98. Which of the following is NOT a characteristic of meristematic cells?
(A) Large central vacuole and ergastic substances.
(B) Dense cytoplasm and prominent nucleus.
(C) Thin cellulosic cell walls.
(D) High rate of metabolism.

99. In the context of the shoot apex, the youngest leaf primordium is found:
(A) At the base of the shoot.
(B) Farthest from the apical meristem.
(C) Closest to the apical meristem.
(D) In the axil of a mature leaf.

100. Consider the following statements about anomalous secondary growth:
I It is the deviation from the normal type of secondary growth.
II Stems of Bignonia show anomalous growth with furrowed xylem.
III Monocots like Dracaena exhibit anomalous secondary growth.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

101. The vascular bundles in a dicot leaf are described as:
(A) Conjoint, collateral, and open
(B) Radial and exarch
(C) Conjoint, collateral, and closed
(D) Conjoint, bicollateral, and open

102. In a floral meristem, the homeotic gene 'C' in Arabidopsis is responsible for specifying the identity of which two whorls?
(A) Sepals and Petals
(B) Stamens and Carpels
(C) Petals and Stamens
(D) Sepals and Carpels

103. The term "microsporogenesis" and "megasporogenesis" both involve which type of cell division?
(A) Mitosis
(B) Amitosis
(C) Cytokinesis only
(D) Meiosis

104. A bisporic embryo sac develops from:
(A) Two megaspore nuclei from the megaspore tetrad.
(B) A single megaspore nucleus.
(C) All four megaspore nuclei.
(D) The nucellar cells directly.

105. Allogamy is a type of pollination that ensures:
(A) Self-pollination within the same flower.
(B) Pollination between two flowers on the same plant.
(C) Cross-pollination between flowers of two different plants.
(D) Pollination without any external agency.

106. Gametophytic self-incompatibility is controlled by:
(A) The genotype of the pollen grain itself.
(B) The genotype of the sporophytic tissue of the stigma.
(C) The interaction between the exine and the stigmatic surface.
(D) Environmental factors such as temperature and humidity.

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107. The main function of the endosperm is to:
(A) Protect the embryo.
(B) Form the seed coat.
(C) Help in seed dispersal.
(D) Provide nutrition to the developing embryo.

108. In dicot embryo development, the suspensor's primary function is to:

4. Produces secondary vascular tissues
(A) P-4, Q-1, R-2, S-3
(B) P-3, Q-2, R-4, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

156. The growth of a plant organ in length is referred to as:
(A) Secondary growth
(B) Primary growth
(C) Anomalous growth
(D) Diffuse growth

157. Identify the incorrect statement regarding the shoot apical meristem (SAM).
(A) It is responsible for the formation of leaves and axillary buds.
(B) It is typically dome-shaped.
(C) It is protected by a root cap.
(D) It has distinct zones of cells like the central zone and peripheral zone.

158. Medullary bundles (vascular bundles present in the pith) are a form of primary anomalous structure found in the stems of plants like:
(A) Dracaena and Yucca
(B) Strychnos and Bignonia
(C) Zea mays and Triticum
(D) Amaranthus and Boerhaavia

159. The arrangement of veins and veinlets in the lamina of a leaf is termed:
(A) Venation
(B) Phyllotaxy
(C) Vernation
(D) Prefoliation

160. Which environmental factor is the most critical external cue for inducing the transition to flowering in many plants?
(A) Water availability
(B) Photoperiod (day length)
(C) Soil pH
(D) Nutrient concentration

161. A male gametophyte in angiosperms at the time of shedding is typically:
(A) Single-celled
(B) Two or three-celled
(C) Four-celled
(D) A multicellular structure

162. The basal part of the ovule, from which the integuments and nucellus originate, is called the:
(A) Chalaza
(B) Micropyle
(C) Funicle
(D) Hilum

163. The function of antipodal cells in the embryo sac is:
(A) To guide the growth of the pollen tube into the mature embryo sac.
(B) To develop into the primary embryo tissues following the syngamy.
(C) Generally considered to be nutritive, though they often degenerate rapidly.
(D) To fuse with the male gamete to form the triploid endosperm.

164. Cleistogamous flowers are those which:
(A) Are brightly colored to attract insects.
(B) Lack a perianth.
(C) Open only at night.
(D) Remain closed, ensuring self-pollination.

165. Consider the following statements about post-fertilization events:
I The ovary develops into the fruit.
II The ovule develops into the seed.
III The zygote develops into the embryo.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

166. A student observes that the endosperm in a seed has been completely consumed by the embryo. Such a seed is characteristic of:
(A) Castor
(B) Pea
(C) Maize
(D) Wheat

167. The Onagraceae type of embryo development is characterized by:
(A) Both the apical and basal cells contributing to the embryo proper.
(B) The suspensor being very large and haustorial.
(C) The zygote dividing vertically first.

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(D) The basal cell playing a minor role or forming a small suspensor.

168. A schizocarpic fruit is a dry fruit that:
(A) Splits into single-seeded parts (mericarps) at maturity.
(B) Dehisces along multiple sutures to release seeds.
(C) Has a fleshy pericarp and a single seed.
(D) Develops from an entire inflorescence.

169. What is the primary advantage of vegetative propagation for a horticulturist?
(A) It introduces genetic variation.
(B) It is a slow and complex process.
(C) It preserves the genetic traits of the parent plant.
(D) It always results in disease-free plants.

170. Which of the following is an example of a sucker, a type of vegetative propagule?
(A) Mint and Chrysanthemum
(B) Strawberry and Vallisneria
(C) Ginger and Turmeric
(D) Potato and Artichoke

171. The 'quiescent centre' theory for the root apex was proposed by:
(A) Hanstein
(B) Schmidt
(C) Nageli
(D) Clowes

172. The presence of a polyarch radial vascular bundle is a distinguishing feature of:
(A) Dicot stem
(B) Monocot root
(C) Dicot root
(D) Monocot stem

173. Climbing roots are a modification for mechanical support found in plants like:
(A) Mangroves
(B) Banyan
(C) Pothos (money plant) and Ivy
(D) Sugarcane

174. The function of ray initials in the vascular cambium is to produce:
(A) Secondary xylem and phloem elements of the axial system.
(B) Cork and secondary cortex.
(C) Sieve tubes and companion cells only.
(D) Parenchymatous rays for radial conduction and storage.

175. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): Secondary growth does not occur in monocot stems in the typical manner.
Reason (R): Monocot stems lack a vascular cambium between their xylem and phloem.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

176. Tyloses, which are balloon-like ingrowths into the lumen of vessels, are formed in:
(A) Sapwood during active water transport.
(B) Heartwood, leading to the blockage of vessels.
(C) Secondary phloem to store food.
(D) The cortex during periderm formation.

177. Which of the following is a primary anomalous structure in stems?
(A) Successive rings of vascular cambium
(B) Scattered vascular bundles
(C) Furrowed xylem
(D) Presence of cork

178. Reticulate venation is a characteristic feature of the leaves of:
(A) Most dicotyledons
(B) Most monocotyledons
(C) Gymnosperms
(D) Grasses

179. A plant with Kranz anatomy in its leaves is adapted for:
(A) Surviving in cold climates.
(B) Floating in aquatic environments.
(C) C4 photosynthesis, often in high temperature and light conditions.
(D) Reducing water loss through CAM photosynthesis.

180. Arrange the following stages of dicot embryo development in the correct order:

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I Torpedo stage
II Zygote
III Globular stage
IV Heart stage
(A) II, IV, III, I
(B) I, III, IV, II
(C) II, III, I, IV
(D) II, III, IV, I

181. In the ABC model, a flower lacking A-function genes would have the whorls arranged as:
(A) Sepal, Petal, Stamen, Carpel
(B) Carpel, Stamen, Stamen, Carpel
(C) Petal, Petal, Stamen, Stamen
(D) Sepal, Sepal, Carpel, Carpel

182. A dithecous anther is characterized by having:
(A) One lobe and two microsporangia.
(B) Two lobes and four microsporangia.
(C) Two lobes and two microsporangia.
(D) Four lobes and four microsporangia.

183. The nutritive tissue for the developing embryo in gymnosperms is _____ and in angiosperms is _____.
(A) triploid; haploid
(B) haploid; triploid
(C) diploid; triploid
(D) haploid; diploid

184. In sporophytic self-incompatibility, the rejection or acceptance of pollen is determined by the:
(A) Genotype of the diploid sporophytic tissue of the plant that produced the pollen.
(B) Genotype of the individual pollen grain.
(C) Ploidy level of the endosperm.
(D) Presence of a filiform apparatus.

185. A fruit that develops from a multicarpellary, syncarpous gynoecium can be:
(A) An aggregate fruit
(B) A simple fruit like a berry or capsule
(C) A multiple fruit
(D) Always a false fruit

186. The phenomenon of a single seed giving rise to multiple embryos is known as:
(A) Polyembryony
(B) Parthenocarpy
(C) Apomixis
(D) Somatic embryogenesis

187. In vegetative propagation by layering, what is the key advantage over taking a cutting?
(A) It is a much faster method.
(B) It can be done with any part of the plant.
(C) It introduces more genetic variability.
(D) The propagule receives water and nutrients from the parent plant until it has rooted.

188. Promeristem is the region of:
(A) Permanent tissues.
(B) Early embryonic, undifferentiated meristematic cells.
(C) Differentiating tissues.
(D) Secondary meristem.

189. Root pockets, instead of root caps, are found in:
(A) Xerophytes
(B) Halophytes
(C) Aquatic plants
(D) Epiphytes

190. Match the items in List I with the items in List II and select the correct option.
List I: (Structure)
P. Endosperm
Q. Nucellus
R. Egg Cell
S. Zygote
List II: (Ploidy in a typical angiosperm)
1. n
2. 2n
3. 3n
4. 2n
(A) P-3, Q-2, R-1, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-2, R-1, S-2

191. The stele of a plant consists of all tissues:
(A) Inside the endodermis, including the pericycle, vascular bundles, and pith.
(B) Outside the vascular cambium.
(C) Comprising the cortex and epidermis.
(D) In the apical meristem.

192. Which of the following is NOT a function of the root system?
(A) Anchorage of the plant.
(B) Synthesis of plant growth regulators.
(C) Absorption of water and minerals.
(D) Synthesis of carbohydrates through

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photosynthesis.

193. Phellogen (cork cambium) is a secondary meristem that arises from permanent tissue in the:
(A) Phloem
(B) Epidermis or cortex
(C) Xylem
(D) Pith

194. Consider the following statements and select the correct option.
Statement I: The arrangement of vascular bundles in a monocot stem is described as 'atactostele'.
Statement II: The atactostele lacks a defined pith and cortex.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

195. A leaf that lacks a petiole and is directly attached to the stem is called:
(A) Petiolate
(B) Stipulate
(C) Sessile
(D) Pinnate

196. The two male gametes in an angiosperm pollen tube are formed by the mitotic division of the:
(A) Vegetative cell
(B) Tube nucleus
(C) Microspore mother cell
(D) Generative cell

197. The embryo sac of the Oenothera type is:
(A) Monosporic, 8-nucleate
(B) Bisporic, 8-nucleate
(C) Monosporic, 4-nucleate
(D) Tetrasporic, 16-nucleate

198. The most appropriate term for pollination that occurs between two different flowers on the same plant is:
(A) Autogamy
(B) Geitonogamy
(C) Xenogamy
(D) Cleistogamy

199. What is the morphological nature of the white fleshy edible part of a litchi fruit?
(A) Mesocarp
(B) Endosperm
(C) Thalamus
(D) Fleshy aril

200. Consider the following statements about seed structure:
I The seed coat develops from the integuments of the ovule.
II The micropyle may persist as a small pore in the seed coat.
III The embryo consists of an embryonal axis and cotyledons.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

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201. Micropropagation is a technique of:
(A) Propagating plants through seeds on a large scale.
(B) Growing microorganisms in a laboratory.
(C) Rapidly multiplying plant material in vitro to produce many progeny plants.
(D) Creating hybrid plants through pollen culture.

202. The vascular cambium cuts off more secondary xylem on the inner side than secondary phloem on the outer side because:
(A) The fusiform initials are more active towards the inner side.
(B) The secondary phloem gets crushed during secondary growth.
(C) The secondary xylem cells are smaller in size.
(D) Environmental conditions favor xylem production.

203. The term 'phyllode' refers to a modification where the:
(A) Stem is modified to look like a leaf.
(B) Leaf is modified into a spine.
(C) Entire leaf is modified to form a pitcher.
(D) Petiole is flattened and green, taking the shape and function of a leaf.

204. In the vascular bundle of a leaf, xylem is typically located towards the _____ surface and phloem towards the _____ surface.
(A) abaxial; adaxial
(B) adaxial; abaxial
(C) marginal; central
(D) central; marginal

205. The primary function of the endothecium in an anther wall is:
(A) Nutrition
(B) Protection
(C) Aiding in anther dehiscence
(D) Producing pollen grains

206. An ovule is attached to the placenta by a stalk called the:
(A) Hilum
(B) Raphe
(C) Nucellus
(D) Funicle

207. Which pollination mechanism would be most effective for a flower that is small, non-fragrant, and produces a large amount of light, dry pollen?
(A) Anemophily (wind)
(B) Entomophily (insects)
(C) Ornithophily (birds)
(D) Malacophily (snails)

208. The development of a fruit from an unfertilized ovary is called:
(A) Parthenogenesis
(B) Parthenocarpy
(C) Apomixis
(D) Apospory

209. A caryopsis is a type of dry, indehiscent fruit where the:
(A) Pericarp is free from the seed coat.
(B) Pericarp is fused with the seed coat.
(C) Fruit develops from an inferior ovary.
(D) Fruit has a winged pericarp.

210. The mass of parenchymatous tissue within the integuments of an ovule is the:
(A) Nucellus
(B) Endosperm
(C) Embryo sac
(D) Chalaza

211. The Tunica-Corpus theory is used to explain the organization of the:
(A) Root apical meristem
(B) Vascular cambium
(C) Shoot apical meristem
(D) Floral meristem

212. Assimilatory roots, which are green and photosynthetic, are found in plants like:
(A) Vanda
(B) Ficus
(C) Rhizophora
(D) Tinospora and Trapa

213. When the cambium forms a complete, continuous ring, it is because the:
(A) Intrafascicular cambium becomes active.
(B) Pericycle cells become meristematic.
(C) Interfascicular cambium develops from medullary rays and joins the intrafascicular cambium.
(D) Hypodermal cells dedifferentiate to form cambium.

214. The term 'bark' in a non-technical sense refers to:
(A) Just the cork layer.
(B) All tissues exterior to the vascular cambium.
(C) The secondary phloem.
(D) The periderm and cortex.

215. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): In Arabidopsis, a mutation in a C-class gene results in a flower with sepals and petals in all four whorls.
Reason (R): The C-class gene is required for stamen and carpel identity, and in its absence, the A-class gene function expands to all four whorls.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

216. The development of a male gamete without fertilization is known as:
(A) Androgenesis
(B) Parthenogenesis

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of inner walls and protoplast fusion.
(B) Secretory tapetum provides more nutrition.
(C) Only secretory tapetum has dense cytoplasm.
(D) Only amoeboid tapetum is polyploid.

240. The structure that guides the pollen tube from the stigma to the ovule is the:
(A) Ovary wall
(B) Style
(C) Filament
(D) Pedicel

241. What is the primary function of the polar nuclei in the central cell of the embryo sac?
(A) To nourish the egg cell before fertilization.
(B) To fuse with a male gamete to form the primary endosperm nucleus.
(C) To degenerate after fertilization.
(D) To guide the entry of the pollen tube.

242. The endosperm is a triploid tissue in most angiosperms, but in Oenothera it is:
(A) Diploid (2n)
(B) Haploid (n)
(C) Tetraploid (4n)
(D) Pentaploid (5n)

243. In a typical dicot embryo, the radicle gives rise to the:
(A) Shoot system
(B) Cotyledons
(C) Primary root
(D) Endosperm

244. A legume fruit (pod) is a simple, dry fruit that develops from a:
(A) Bicarpellary, syncarpous ovary and splits into mericarps.
(B) Multicarpellary, apocarpous gynoecium.
(C) Syncarpous ovary with parietal placentation.
(D) Monocarpellary ovary and dehisces along both sutures.

245. Consider the following statements about seed dispersal:
I Zoochory is dispersal by animals.
II Anemochory is dispersal by wind.
III Hydrochory is dispersal by water.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

246. Which part of the root apical meristem is responsible for the formation of the cortex?
(A) Dermatogen
(B) Periblem
(C) Plerome
(D) Calyptrogen

247. Respiratory or knee roots (pneumatophores) are a characteristic adaptation of plants growing in:
(A) Deserts
(B) Alpine regions
(C) Temperate forests
(D) Marshy, saline swamps

248. The age of a tree can be estimated by:
(A) Counting the number of annual rings in the trunk.
(B) Counting the number of secondary phloem layers.
(C) Measuring the height of the tree.
(D) Measuring the girth of the trunk.

249. A thorn is a modified:
(A) Leaf
(B) Root
(C) Axillary bud or stem
(D) Stipule

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250. The mesophyll tissue in a monocot leaf is typically:
(A) Undifferentiated and consists of isodiametric chlorenchyma cells.
(B) Differentiated into palisade and spongy parenchyma.
(C) Composed of only palisade parenchyma.
(D) Lignified and provides mechanical support.

251. The floral formula symbol G(2) represents a:
(A) Gynoecium of two free carpels.
(B) Gynoecium with an inferior ovary and two free carpels.
(C) Sterile pistil (pistillode).
(D) Gynoecium with a superior ovary and two fused carpels.

252. The germ pore in a pollen grain is a region where the:

228. Herkogamy is a floral mechanism that promotes cross-pollination by:
(A) Having the anthers and stigma mature at different times.
(B) Genetic self-incompatibility.
(C) The production of unisexual flowers.
(D) The spatial separation of the anthers and stigma within a flower.

229. If a fruit develops from an inflorescence, it is called a(n):
(A) Aggregate fruit
(B) Simple fruit
(C) Multiple fruit
(D) Parthenocarpic fruit

230. Match the items in List I with the items in List II and select the correct option.
List I: (Type of Fruit)
P. Drupe
Q. Berry
R. Pome
S. Hesperidium
List II: (Example)
1. Tomato
2. Orange
3. Mango
4. Pear
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-4, R-1, S-3

231. In layering, a technique for vegetative propagation, the part of the plant that is induced to root is a:
(A) Leaf
(B) Root
(C) Flower
(D) Stem

232. In a mature dicot root that has undergone secondary growth, the primary xylem is located:
(A) At the center of the stele.
(B) At the periphery of the vascular cylinder.
(C) Scattered throughout the secondary xylem.
(D) Just outside the vascular cambium.

233. In the root-nodule symbiosis of legumes, the Rhizobium bacteria provide the plant with _____, and the plant provides the bacteria with _____.
(A) carbohydrates; fixed nitrogen
(B) phosphorus; water
(C) fixed nitrogen; carbohydrates
(D) water; phosphorus

234. The presence of conjoint, collateral, and closed vascular bundles scattered in a ground tissue is a characteristic feature of:
(A) Monocot stem
(B) Dicot stem
(C) Dicot root
(D) Monocot root

235. The phelloderm, or secondary cortex, is formed by the phellogen (cork cambium) on its:
(A) Outer side
(B) Lateral sides
(C) Both outer and inner sides equally
(D) Inner side

236. The primary anomalous structure seen in the stem of Nyctanthes is:
(A) Scattered vascular bundles.
(B) Cortical vascular bundles.
(C) Medullary vascular bundles.
(D) Bicollateral vascular bundles.

237. A compound leaf is distinguished from a simple leaf by:
(A) The presence of a petiole.
(B) The presence of reticulate venation.
(C) The division of the lamina into multiple leaflets.
(D) The absence of an axillary bud at the base of the petiole.

238. A mutation in Arabidopsis that knocks out the function of all three classes of floral identity genes (A, B, and C) would likely result in the formation of:
(A) A normal flower
(B) Only stamens
(C) Only carpels
(D) Structures resembling leaves in all whorls

239. The tapetum of the anther wall can be of two types: amoeboid (plasmodial) and secretory (glandular). The primary difference is that:
(A) Amoeboid tapetum involves the breakdown

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(C) Apospory
(D) Diplospory

217. Identify the incorrect statement about double fertilization.
(A) It is a characteristic feature of all angiosperms.
(B) It involves the fusion of two male gametes with two different cells of the embryo sac.
(C) It results in the formation of a diploid zygote and a diploid endosperm.
(D) It was discovered by Nawaschin.

218. An embryo that develops from a cell of the embryo sac other than the egg cell is an example of:
(A) Apogamy
(B) Adventive embryony
(C) Cleavage polyembryony
(D) Aposporous embryony

219. A 'sorosis' is a type of multiple fruit that develops from a:
(A) Hypanthodium inflorescence
(B) Cyathium inflorescence
(C) Capitulum inflorescence
(D) Spike or spadix inflorescence

220. The viability of a seed refers to its ability to:
(A) Remain dormant for a long period.
(B) Germinate under suitable environmental conditions.
(C) Be dispersed over long distances.
(D) Resist microbial attacks.

221. A bulbil is a vegetative propagule that is essentially a:
(A) Modified fleshy root
(B) Swollen underground stem
(C) Modified fleshy leaf bud
(D) Elongated runner

222. The function of the quiescent centre is to:
(A) Actively divide and contribute to root length.
(B) Store food for the root tip.
(C) Perceive gravity.
(D) Resist damage and act as a reservoir for restoring the meristem.

223. What type of anomalous secondary growth is characterized by the formation of phloem wedges embedded in the secondary xylem?
(A) Furrowed xylem as in Bignonia.
(B) Successive cambial rings as in Boerhaavia.
(C) Cambium activity restricted to strips as in Aristolochia.
(D) Presence of medullary bundles.

224. Which of the following is an adaptation for photosynthesis in a typical dicot leaf?
(A) A thick, waxy cuticle on both surfaces.
(B) Stomata concentrated on the lower epidermis to facilitate gas exchange while minimizing water loss.
(C) Tightly packed spongy mesophyll with no air spaces.
(D) The presence of a sclerenchymatous hypodermis.

225. Arrange the following events in the correct sequence for the development of a female gametophyte (Polygonum type).
I Meiosis in megaspore mother cell.
II Degeneration of three megaspores.
III Three successive mitotic divisions of the functional megaspore nucleus.
IV Formation of a 7-celled, 8-nucleate embryo sac.
(A) I, III, II, IV
(B) I, II, III, IV
(C) II, I, III, IV
(D) I, III, IV, II

226. What is the key difference between a stamen and a staminode?
(A) A stamen is fertile, and a staminode is sterile.
(B) A stamen is male, and a staminode is female.
(C) A stamen is part of the corolla, and a staminode is part of the calyx.
(D) A stamen has a filament, while a staminode does not.

227. A tenuinucellate ovule is one in which the:
(A) Nucellus is massive and well-developed.
(B) Integuments are absent.
(C) Nucellus is single-layered or poorly developed.
(D) Embryo sac develops from the nucellar tissue.

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(A) Exine is thickest.
(B) Exine is absent or very thin.
(C) Intine is absent.
(D) Vegetative nucleus is located.

253. A crassinucellate ovule is characterized by a:
(A) Thin, single-layered nucellus.
(B) Lack of integuments.
(C) Massive, well-developed nucellus.
(D) Curved embryo sac.

254. Ornithophily refers to pollination by:
(A) Wind
(B) Water
(C) Insects
(D) Birds

255. Select the correct option based on the Assertion (A) and Reason (R) given below.
Assertion (A): The endosperm supplies nutrition to the developing embryo.
Reason (R): The endosperm is a product of triple fusion and is typically triploid.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

256. A scion is grafted onto a stock. The quality of the fruit produced will be determined by the genotype of the:
(A) Stock
(B) Scion
(C) Both stock and scion equally
(D) Soil in which the stock is grown

257. An example of a root modification for storage that is a fasciculated tuberous root is:
(A) Radish
(B) Dahlia
(C) Carrot
(D) Turnip

258. Secondary phloem is a complex tissue that remains functional for a shorter duration than secondary xylem because:
(A) Its conducting elements (sieve tubes) are delicate and lack nuclei at maturity, eventually being crushed.
(B) It is produced in smaller quantities.
(C) It transforms into heartwood.
(D) It is located on the inner side of the cambium.

259. When tendrils develop from the axillary bud, as in grapevine, they are considered to be modified:
(A) Leaves
(B) Stipules
(C) Stems
(D) Inflorescences

260. A plant is found to have stomata equally distributed on both leaf surfaces and an undifferentiated mesophyll. This leaf is likely:
(A) Dorsiventral and dicotyledonous
(B) Xerophytic with sunken stomata
(C) A submerged hydrophytic leaf
(D) Isobilateral and monocotyledonous

261. According to the ABC model, which gene activity is required for the development of petals?
(A) A only
(B) B only
(C) A and B together
(D) C only

262. The process of the formation and differentiation of microspores from microspore mother cells is:
(A) Megasporogenesis
(B) Microsporogenesis
(C) Gametogenesis
(D) Embryogenesis

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263. An orthotropous ovule is characterized by:
(A) Being completely inverted.
(B) Being curved at a right angle to the funicle.
(C) Having a curved embryo sac.
(D) Being straight, with the micropyle, chalaza, and funicle in a single line.

264. What is the ploidy of antipodal cells in a typical Polygonum-type embryo sac?
(A) Haploid (n)
(B) Diploid (2n)
(C) Triploid (3n)
(D) Polyploid

265. An example of a plant that shows hydrophily (pollination by water) is:
(A) Rose

(B) Maize
(C) Vallisneria
(D) Sunflower

266. A plant breeder wants to prevent self-pollination in a bisexual flower to perform a cross. The first step they should perform is:
(A) Emasculation
(B) Bagging
(C) Pollination
(D) Tagging

267. In cellular type of endosperm development, wall formation:
(A) Does not occur.
(B) Occurs only after hundreds of nuclear divisions.
(C) Occurs only in the micropylar chamber.
(D) Follows every nuclear division of the primary endosperm nucleus.

268. In the Asterad type of embryogeny, the basal cell:
(A) Divides repeatedly to form a large suspensor.
(B) Contributes significantly to the embryo proper.
(C) Undergoes little or no division.
(D) Develops into the endosperm.

269. The edible part of a coconut is the:
(A) Pericarp
(B) Embryo
(C) Endosperm
(D) Seed coat

270. A seed that contains food reserves in its endosperm is called:
(A) Exalbuminous
(B) Perispermic
(C) Apomictic
(D) Albuminous

271. Offset is a type of vegetative propagule found in aquatic plants like:
(A) Pistia and Eichhornia
(B) Mint and Jasmine
(C) Banana and Pineapple
(D) Grass and Strawberry

272. The outermost layer of the stele in a root is the:
(A) Endodermis
(B) Pericycle
(C) Cortex
(D) Epidermis

273. The velamen tissue in epiphytic roots is a specialized, multi-layered:
(A) Cortex
(B) Epidermis
(C) Pericycle
(D) Pith

274. In a vascular bundle, if the xylem surrounds the phloem, it is called:
(A) Amphivasal
(B) Amphicribral
(C) Collateral
(D) Bicollateral

275. Match the items in List I with the items in List II and select the correct option.
List I: (Plant)
P. Dracaena
Q. Boerhaavia
R. Bignonia
S. Strychnos
List II: (Anomalous Structure)
1. Phloem wedges in xylem
2. Medullary vascular bundles
3. Successive rings of cambium
4. Monocot secondary growth
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

276. The loss of water in liquid form from the tips of grass blades or leaf margins is known as:
(A) Transpiration
(B) Exudation
(C) Bleeding
(D) Guttation

277. The term 'syngenesious' refers to the condition where:
(A) Stamens are fused by their filaments into a single bundle.
(B) Stamens are fused to the petals.
(C) Stamens are fused by their anthers, but filaments are free.
(D) Both anthers and filaments are fused.

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278. In a pollen grain, the vegetative cell is larger and has an irregularly shaped nucleus, while the generative cell is:
(A) Also large with a large nucleus.
(B) Small, spindle-shaped, and floats in the cytoplasm of the vegetative cell.
(C) The non-functional cell that degenerates.
(D) Responsible for forming the pollen tube.

279. The embryo sac type found in Allium is:
(A) Monosporic
(B) Tetrasporic
(C) Aposporic
(D) Bisporic

280. What is the most significant outcome of double fertilization?
(A) It ensures that the nutritive tissue (endosperm) is formed only if fertilization of the egg occurs.
(B) It leads to the formation of a diploid embryo only.
(C) It allows for the fusion of multiple pollen grains with one embryo sac.
(D) It creates genetic variation through the fusion of polar nuclei.

281. The pericarp of a fruit is differentiated into:
(A) Testa and tegmen
(B) Coleoptile and coleorhiza
(C) Epicarp, mesocarp, and endocarp
(D) Calyx, corolla, and androecium

282. Adventive embryony, where an embryo develops directly from a diploid cell of the nucellus or integument, is a type of:
(A) Apomixis (sporophytic budding)
(B) Sexual reproduction
(C) Parthenogenesis
(D) Cleavage polyembryony

283. Layering is commercially used for the propagation of plants like:
(A) Wheat and Rice
(B) Potato and Ginger
(C) Rose and Sugarcane
(D) Jasmine and Bougainvillea

284. A dicot stem is identified by the presence of:
(A) Scattered vascular bundles.
(B) Vascular bundles arranged in a ring (eustele).
(C) Absence of a cambium.
(D) Polyarch xylem.

285. Consider the following statements about periderm:
I It is a protective tissue that replaces the epidermis.
II It consists of phellogen, phellem, and phelloderm.
III Phellogen forms phellem on the outside and phelloderm on the inside.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

286. A leaf is attached to the stem at a _____ and bears a bud in its _____.
(A) internode; axil
(B) axil; node
(C) node; internode
(D) node; axil

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287. In a flower of Arabidopsis where A-function is normal but B-function is lost, the floral organs would be:
(A) Sepal, Sepal, Carpel, Carpel
(B) Sepal, Petal, Stamen, Carpel
(C) Petal, Petal, Stamen, Stamen
(D) Carpel, Carpel, Sepal, Sepal

288. The most resistant biological material known, which composes the pollen exine, is:
(A) Lignin
(B) Sporopollenin
(C) Cutin
(D) Suberin

289. The entry of the pollen tube into the ovule through the integuments is known as:
(A) Porogamy
(B) Mesogamy
(C) Chalazogamy
(D) Syngamy

290. When the pericarp is dry and splits open at maturity to release seeds, the fruit is classified as:
(A) Dry dehiscent

carpels. These specific combinations ensure that each whorl develops into its correct biological structure.

46. (D) Sepal, Sepal, Carpel, Carpel
In the ABC model, B-class genes are essential for specifying petals and stamens. If B function is lost, the second whorl expresses only A-class genes, resulting in sepals instead of petals. Similarly, the third whorl expresses only C-class genes, resulting in carpels instead of stamens. Consequently, the flower arrangement from outside to inside becomes sepal, sepal, carpel, and finally another carpel.

47. (A) The anther and the filament
The stamen is the male reproductive organ of a flower, collectively forming the androecium. It consists of two main parts: the anther and the filament. The anther is a pollen-bearing structure, typically consisting of two lobes, while the filament is a slender stalk that supports the anther and positions it for effective pollen dispersal by various wind or animal agents.

48. (B) Tapetum
The anther wall is composed of several layers, each with a specific function. The tapetum is the innermost layer and is characterized by cells with dense cytoplasm and often more than one nucleus. Its primary role is to provide essential nutrients to the developing microspores. It also contributes to the formation of the pollen wall and secretes enzymes and various other proteins.

49. (B) Microspore tetrads from a microspore mother cell through meiosis.
Microsporogenesis is the biological process by which microspores are formed within the microsporangium of an anther. During this process, a diploid microspore mother cell undergoes meiosis to produce four haploid microspores. These microspores are initially arranged in a cluster known as a tetrad. As the anther matures and dehydrates, the microspores separate and eventually develop into individual, mature pollen grains.

50. (A) One mitotic division of the microspore nucleus to form a vegetative and a generative cell.
The development of the male gametophyte begins within the microspore. The nucleus of the microspore undergoes a mitotic division to produce two unequal cells: a large vegetative cell and a smaller generative cell. The vegetative cell provides nutrients and forms the pollen tube, while the generative cell eventually divides again to produce the two male gametes required for double fertilization.

51. (C) Stigma, style, and ovary
The pistil, or carpel, represents the female reproductive organ of a flower. It consists of three essential parts: the stigma, which receives the pollen grains; the style, a slender tube through which the pollen tube grows; and the ovary, the enlarged basal portion containing the ovules. After fertilization, the ovary matures into a fruit, and the ovules develop into seeds.

52. (D) Anatropous
An anatropous ovule is the most common type found in angiosperms. It is characterized by being completely inverted, which brings the micropyle close to the funicle. This orientation is achieved through the unequal growth of the funicle. In this position, the chalaza and micropyle are aligned in a straight line, while the micropyle faces the base of the supporting funicle.

53. (C) The megaspore mother cell undergoes meiosis to form a linear tetrad of megaspores.
Megasporogenesis is the process of forming megaspores within the ovule's nucellus. A single diploid megaspore mother cell undergoes meiotic division, resulting in the production of four haploid megaspores. These megaspores are typically arranged in a linear tetrad. This process is a critical step in the development of the female gametophyte, which will eventually house the egg cell for future fertilization.

54. (B) Three degenerate, and one functional megaspore develops into the embryo sac.
Following the process of megasporogenesis, four haploid megaspores are formed in a linear tetrad. In most angiosperms, only one of these megaspores, usually the one furthest from the micropyle, remains functional. The other three megaspores eventually degenerate. This functional megaspore then undergoes several mitotic divisions to develop into the mature female gametophyte, also known as the embryo sac.

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ANSWERS

1. (B) It is composed of actively dividing, undifferentiated cells.
Meristematic tissues are specialized regions of plant growth where cells remain in a continuous state of division. These cells are characterized by being undifferentiated, meaning they have not yet developed into a specific tissue type. This perpetual mitotic activity allows the plant to produce new cells for growth, repair, and the development of various organs throughout its entire life cycle.

2. (A) Intercalary meristem
Intercalary meristems are localized between regions of mature or permanent tissues, specifically at the base of nodes or internodes. In plants like grasses, these meristems facilitate the elongation of stems and the regrowth of parts removed by grazing. This positioning allows for rapid longitudinal growth and vertical extension, distinguishing it from the primary growth occurring at the apical and lateral regions.

3. (A) Both Statement I and Statement II are true.
In roots, the apical meristem is situated slightly behind the tip because it is covered and protected by a root cap, making its position sub-terminal. Conversely, the shoot apical meristem is terminal, located at the very tip of the stem. This region is actively involved in generating new growth, including the production of leaf primordia during the early stages of development.

4. (D) Intrafascicular cambium
Primary meristems originate directly from the embryonic cells and contribute to the primary growth of the plant body. The intrafascicular cambium, located within the vascular bundles of dicot stems, is considered a primary meristem because it is present from the initial stages of tissue development. Other options like cork cambium and interfascicular cambium are secondary meristems formed later in plant life.

5. (A) P-3, Q-4, R-1, S-2
Meristems are classified by their location and origin. The apical meristem is found at the root apex, while the intercalary meristem is found at the base of mint leaves. The lateral meristem is exemplified by the cork cambium, which is responsible for secondary growth. Finally, the procambium serves as a primary meristem that eventually gives rise to the primary vascular tissues.

6. (B) Acting as a reservoir of cells to replace damaged meristematic cells.
The quiescent center is a region within the root apical meristem where cell division occurs very slowly. These cells contain lower amounts of RNA, DNA, and proteins compared to surrounding cells. Their primary function is to serve as a reserve of healthy cells that can be activated to divide and replace damaged meristematic tissue, ensuring the continued growth of the root system.

7. (D) The ground meristem differentiates into the cortex.
During the primary growth of a root, the apical meristem produces three primary meristematic tissues: protoderm, procambium, and ground meristem. The protoderm eventually forms the epidermis, while the procambium gives rise to the vascular cylinder, including xylem and phloem. The ground meristem is responsible for forming the fundamental tissues of the plant, such as the cortex and the endodermis within the root.

8. (A) Both A and R are true and R is the correct explanation of A.
The root cap is a protective structure that covers the delicate apical meristem as the root grows through the abrasive soil. It consists of parenchymatous cells that constantly wear away and are replaced. These cells secrete a mucilaginous substance that acts as a lubricant, facilitating the smooth passage of the root tip through soil particles while preventing mechanical damage to tissues.

9. (C) A large and well-developed pith is present in the center.
A typical dicot root is characterized by an extensive cortex and an exarch xylem arrangement, which

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is usually diarch to tetrarch. Unlike monocot roots, dicot roots generally possess a very small or completely absent pith at the center of the vascular cylinder. During secondary growth, this central region is often filled with secondary xylem, further reducing the space available for pith tissue.

10. (A) Polyarch and exarch
Monocot roots are distinguished by having many vascular bundles, a condition known as polyarch, where the number of xylem bundles is typically more than six. The xylem development is exarch, meaning the protoxylem is located towards the periphery and the metaxylem is toward the center. This arrangement, along with a large, well-developed pith, helps differentiate monocot root anatomy from dicot roots.

11. (D) IV, II, III, I
The structure of a root tip shows a distinct sequence of zones starting from the apex. The root cap protects the tip, followed by the zone of cell division where meristematic activity occurs. Above this is the zone of cell elongation, where cells increase in length. Finally, the zone of maturation is where cells differentiate into specialized tissues and root hairs develop.

12. (B) The vascular cambium and the cork cambium.
Secondary growth in dicotyledonous roots results in an increase in thickness and is driven by the activity of two lateral meristems. The vascular cambium produces secondary xylem and secondary phloem, while the cork cambium, or phellogen, produces the protective periderm. Together, these tissues provide the necessary structural support and protection as the root matures and expands in girth over several years.

13. (C) It is partly from the pericycle and partly from the conjunctive tissue.
In dicot roots, the vascular cambium is entirely secondary in origin. It forms from the tissues located just below the phloem bundles, known as conjunctive tissue, and from the portions of the pericycle located outside the protoxylem. These isolated segments of meristematic tissue eventually join to form a continuous, wavy ring of cambium that becomes circular as secondary growth progresses throughout time.

14. (B) II and III only
Root modifications serve various specialized functions in plants. Stilt roots in maize emerge from the lower nodes to provide additional mechanical support, and fleshy tap roots in carrots are specialized for storing food. However, pneumatophores are negatively geotropic respiratory roots that grow upwards in marshy environments to obtain oxygen, making the description of them being positively geotropic in Statement I incorrect.

15. (A) To absorb moisture from the air.
Epiphytic plants, such as certain orchids, possess specialized aerial roots that are covered by a multi-layered, sponge-like tissue called velamen. This tissue is composed of dead cells with thickened walls that can effectively absorb and store moisture and nutrients from the atmosphere. This adaptation allows epiphytes to survive in environments where they do not have direct access to soil-based water.

16. (B) Mycorrhiza
Mycorrhiza is a symbiotic relationship between fungal hyphae and the roots of higher plants. In this association, the fungus assists the plant by increasing the surface area for the absorption of water and essential minerals, particularly phosphorus. In return, the plant provides the fungus with organic nutrients produced through photosynthesis. This mutualistic interaction is vital for the survival of many plant species.

17. (B) Mycorrhizal fungi increase the surface area for water and phosphate absorption.
Symbiotic relationships between roots and microbes are essential for nutrient acquisition. Mycorrhizal fungi extend their hyphae into the soil, significantly increasing the effective surface area for absorbing water and minerals like phosphate. While some bacteria are pathogenic, many others, such as Rhizobium in legumes, are beneficial nitrogen-fixers that live in specialized root nodules to convert atmospheric nitrogen into usable forms.

18. (A) Hanstein
The histogen theory was proposed by Hanstein to explain the organization of the shoot apical meristem. This theory suggests that the meristem consists of three distinct layers of cells, known

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as histogens: the dermatogen, periblem, and plerome. Each of these layers is destined to give rise to specific tissue systems within the plant, such as the epidermis, cortex, and vascular cylinder.

19. (A) Both A and R are true and R is the correct explanation of A.
The Tunica-Corpus theory describes the organization of the shoot apex into two distinct regions. The tunica consists of one or more outer layers where cells divide primarily in an anticlinal direction, leading to an increase in the surface area of the apex. This surface growth is essential for accommodating the expanding internal volume produced by the underlying corpus during plant development.

20. (D) Corpus
According to the Tunica-Corpus theory, the shoot apical meristem is divided into two zones. The tunica forms the outer protective layers, while the corpus is the central mass of cells. The cells in the corpus divide in multiple planes, increasing the volume of the shoot. This region eventually differentiates into the ground tissue, including the cortex and pith, and the vascular tissues.

21. (B) P-3, Q-4, R-1, S-2
Shoot modifications perform diverse roles such as photosynthesis and protection. Phylloclades in Opuntia are fleshy, green stems used for photosynthesis, while cladodes in Asparagus are stems of limited growth. Passiflora utilizes stem tendrils for climbing support, and Bougainvillea features thorns as a defensive mechanism against herbivores. These structures demonstrate the adaptability of stems in response to various environmental pressures and challenges.

22. (B) Dicot stem
A transverse section of a dicot stem is characterized by a distinctive arrangement of vascular bundles. These bundles are conjoint, collateral, and open, and they are typically arranged in a ring-like pattern known as a eustele. This organized structure surrounds a central pith and is separated from the epidermis by the cortex, providing a clear anatomical distinction from the scattered bundles of monocots.

23. (D) Ground tissue is differentiated into cortex, endodermis, and pericycle.
Monocot stems have a unique anatomical structure where the vascular bundles are scattered throughout the ground tissue, a condition called atactostele. These bundles are usually conjoint, collateral, and closed, and they are often surrounded by a protective sclerenchymatous bundle sheath. Unlike dicot stems, the ground tissue in monocots is not differentiated into distinct regions like the cortex, endodermis, pericycle, or pith.

24. (D) I, II, and III
The vascular cambium is a lateral meristem essential for secondary growth in dicotyledonous plants. It consists of two types of cells: fusiform initials, which produce secondary xylem and phloem, and ray initials, which form vascular rays. This meristematic layer produces secondary xylem toward the interior of the stem and secondary phloem toward the exterior, leading to an increase in the stem's girth.

25. (C) Annual or growth rings
The activity of the vascular cambium is highly sensitive to environmental and physiological changes. In temperate regions, cambial activity varies with the seasons, producing wood with different vessel sizes and densities. This results in the formation of distinct concentric layers known as annual or growth rings. Counting these rings in a cross-section of wood allows for the estimation of the tree's chronological age.

26. (A) Has wider vessels and is lighter in color.
Spring wood, also known as early wood, is produced when the vascular cambium is highly active during favorable growing conditions. It is characterized by having wider xylem vessels with thinner walls to facilitate efficient water transport. Due to its lower density and larger vessel size, spring wood appears lighter in color compared to the more compact and darker autumn wood formed later.

27. (D) Dark in color, non-functional, and contains deposits like tannins and resins.
Heartwood is the older, non-functional secondary xylem found at the center of a mature tree trunk. It is distinguished from the outer sapwood by its dark color, which results from the deposition

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of organic compounds like tannins, resins, and oils. These substances make the wood hard and durable, providing mechanical support while resisting decay and microbial attacks, though it no longer conducts water.

28. (B) Periderm
Periderm is a collective term for the protective tissues that replace the epidermis during secondary growth in stems and roots. It consists of the phellogen, which is the meristematic layer, the phellem or cork produced toward the outside, and the phelloderm or secondary cortex produced toward the inside. These layers work together to provide insulation and protection against water loss and environmental damage.

29. (C) II, I, IV, III
In a mature dicot stem undergoing secondary growth, the tissues are arranged in a specific order from the exterior to the interior. The outermost protective layer is the periderm, followed by the secondary phloem. The vascular cambium is the meristematic layer located between the phloem and the secondary xylem, which forms the innermost bulk of the wood within the plant body.

30. (D) Boerhaavia
Boerhaavia exhibits a unique form of anomalous secondary growth where the typical single cambial ring is supplemented or replaced by successive rings of cambium. These additional rings develop in the pericycle or inner cortex and produce both xylem and phloem. This pattern deviates from the standard secondary growth seen in most dicots and is a characteristic adaptation found in certain plant families.

31. (A) A cambium that originates in the ground tissue outside the vascular bundles.
Although Dracaena is a monocot, it exhibits a form of anomalous secondary growth. This process is initiated by a specialized cambial layer that originates in the ground tissue, specifically in the region outside the primary vascular bundles. This cambium produces secondary vascular bundles and additional ground tissue, allowing the stem to increase in diameter, unlike the typical non-growing stems of monocots.

32. (B) Scattered vascular bundles as seen in a monocot stem.
Primary anomalous structures are unusual tissue arrangements that are present from the earliest stages of a plant's development. A prominent example is the scattered distribution of vascular bundles found in monocot stems, known as an atactostele. This arrangement lacks the organized ring of bundles seen in typical dicots and represents a fundamental anatomical variation that occurs without the influence of secondary growth.

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33. (A) Both A and R are true and R is the correct explanation of A.
In some plants like Strychnos, the stem displays a complex primary structure where vascular bundles are arranged in multiple concentric rings. This includes both medullary bundles located in the pith and cortical bundles in the cortex. This deviation from the typical single-ring arrangement is classified as a primary anomalous structure, as it is established during the initial development of the stem.

34. (A) The peripheral zone as a leaf primordium
Leaves originate from the shoot apical meristem as small, specialized protrusions called leaf primordia. These primordia develop specifically from the peripheral zone of the meristem, where cell division is active and targeted toward organogenesis. This localized growth eventually leads to the formation of the leaf blade and petiole, marking the transition from meristematic activity to the development of vegetative organs.

35. (D) P-2, Q-3, R-1
Phyllotaxy refers to the pattern of leaf arrangement on a stem. In alternate phyllotaxy, a single leaf arises at each node in a staggered fashion. Opposite phyllotaxy involves a pair of leaves emerging at each node across from one another. Whorled phyllotaxy is characterized by more than two leaves arising from a single node, forming a circular pattern around the stem.

36. (D) Reticulate
Leaf diversity is often categorized by shape, which includes various forms such as linear, ovate, and lanceolate. Reticulate, however, refers to a specific pattern of venation where veins form a complex network across the leaf surface. While

shape describes the overall silhouette of the leaf, venation describes the internal arrangement of the vascular system, representing a different aspect of leaf morphology.

37. (C) Dicots
A dorsiventral leaf is a characteristic feature of most dicotyledonous plants. These leaves are typically oriented horizontally, exposing the upper surface to direct sunlight. Anatomically, they show a clear differentiation between the upper and lower epidermis, with most stomata located on the lower surface to minimize water loss. The internal mesophyll is also divided into distinct palisade and spongy parenchyma layers.

38. (B) Vascular bundles are of similar sizes and surrounded by a sclerenchymatous sheath.
In a dicot leaf, the vascular bundles vary significantly in size, with the largest bundle located in the midrib and smaller ones in the lateral veins. These bundles are typically surrounded by a layer of parenchymatous cells known as the bundle sheath. Most stomata are concentrated on the abaxial epidermis, and the mesophyll is clearly differentiated into palisade and spongy tissue layers.

39. (D) All of the above.
Isobilateral leaves are typical of monocots and are characterized by several key features. Both the upper and lower surfaces are anatomically similar, usually containing approximately equal numbers of stomata. The mesophyll tissue is typically not differentiated into distinct palisade and spongy layers. Furthermore, these leaves often grow vertically, allowing both sides to receive similar amounts of sunlight during the day.

40. (A) The rolling and unrolling of the leaf in response to water stress
Bulliform cells are large, bubble-shaped epidermal cells found on the upper surface of many monocot leaves, such as grasses. When these cells lose water due to transpiration, they become flaccid, causing the leaf to roll inward. This mechanism reduces the leaf's surface area exposed to the environment, thereby minimizing further water loss during periods of drought or intense heat and stress.

41. (C) Sunken stomata and a thick cuticle.
Xerophytic plants have evolved various anatomical adaptations to conserve water in arid environments. Common features include a thick, waxy cuticle on the leaf surface to reduce evaporation and sunken stomata located in pits or grooves. These modifications create a localized area of high humidity around the stomatal pores, significantly slowing the rate of transpiration and helping the plant survive dry conditions.

42. (A) It is a determinate meristem that produces the four whorls of a flower.
The transition to flowering involves the conversion of the vegetative apical meristem into a floral meristem. Unlike vegetative meristems, which are indeterminate and can grow indefinitely, the floral meristem is determinate. It produces a fixed number of floral organs arranged in four concentric whorls—sepals, petals, stamens, and carpels—after which the activity of the meristematic tissue completely ceases.

43. (D) The identity of the four floral organs (sepals, petals, stamens, carpels) is specified.
The ABC model of floral development is a genetic framework that explains how the identity of floral organs is determined in plants like Arabidopsis. It proposes that three classes of homeotic genes—A, B, and C—act alone or in combination within four concentric whorls. This specific gene expression patterns dictate whether a whorl will develop into sepals, petals, stamens, or carpels.

44. (B) Sepals
According to the ABC model of flower development, each class of genes specifies a particular organ type when expressed. The expression of A-class genes alone in the outermost whorl of the floral meristem leads to the development of sepals. If A-class genes are combined with B-class genes, petals are formed, illustrating how overlapping gene functions create the diversity of floral organs.

45. (D) I, II, and III
The ABC model defines the genetic basis for floral organ identity through the interaction of three gene classes. A and B genes together specify petals, while B and C genes together specify the formation of stamens. C genes acting alone in the innermost whorl determine the development of

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64. (B) The primary endosperm nucleus undergoes repeated mitotic divisions without immediate wall formation.
Nuclear type is the most common form of endosperm development. In this process, the primary endosperm nucleus undergoes several successive mitotic divisions that are not immediately followed by cytokinesis. This results in a large number of free nuclei floating within the central cell. Cell wall formation typically begins later, usually proceeding from the periphery toward the center, eventually making the endosperm tissue cellular.

65. (B) The free-nuclear endosperm.
In a tender coconut, the clear liquid represents the free-nuclear endosperm, consisting of thousands of nuclei suspended in a nutrient-rich fluid. This is a result of the primary endosperm nucleus dividing multiple times without immediate cell wall formation. As the coconut matures, cell walls eventually form around these nuclei, developing into the solid white kernel, which is the cellular endosperm tissue.

66. (A) Helobial type
Helobial endosperm development is an intermediate form between nuclear and cellular types, commonly found in monocots. The first division of the primary endosperm nucleus is followed by a transverse cell wall, dividing the central cell into a large micropylar chamber and a smaller chalazal chamber. Subsequent nuclear divisions in the micropylar chamber are usually free-nuclear, while the chalazal chamber may remain undivided.

67. (C) Post-fertilization tissue formed for nourishing the embryo.
The endosperm is a specialized tissue that develops only after the successful completion of double fertilization in angiosperms. It is formed specifically to provide essential nutrients to the developing embryo during its growth within the seed. Depending on the species, the endosperm may be consumed entirely during seed development or persist as a food storage tissue in the mature seed.

68. (D) Unequal and transverse
In a typical dicot, the first division of the zygote is transverse and unequal, resulting in two distinct cells. The smaller cell, located toward the chalazal end, is the terminal or apical cell, which eventually forms most of the embryo. The larger cell at the micropylar end is the basal cell, which primarily gives rise to the suspensor, a supportive structure.

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69. (C) Torpedo stage
Dicot embryo development follows a series of recognizable morphological stages. After the heart-shaped stage, where the cotyledons begin to form, the embryo enters the torpedo stage. During this phase, the cotyledons elongate significantly, and the primary axes of the embryo become more defined. This stage precedes the final maturation of the embryo, where it prepares for dormancy within the developing seed.

70. (C) The plumule develops into the shoot and the radicle develops into the root.
A mature dicot embryo consists of an embryonal axis and two cotyledons. The axis has two specialized ends: the plumule and the radicle. The plumule is the embryonic shoot that will eventually give rise to the stem and leaves. The radicle is the embryonic root that develops into the primary root system, providing anchorage and nutrient absorption for the young seedling.

71. (D) Scutellum
In monocot seeds, such as those of grasses and cereals, there is only one cotyledon. This structure is large, thin, and shield-shaped, and it is specifically referred to as the scutellum. The scutellum is positioned laterally to the embryonal axis and serves to absorb nutrients from the endosperm and transfer them to the developing embryo during the process of seed germination.

72. (A) Coleorhiza
Monocot embryos possess specialized protective sheaths that cover the ends of the embryonal axis. The radicle and its associated root cap are enclosed within an undifferentiated sheath called the coleorhiza. Similarly, the plumule is protected by a hollow foliar structure known as the coleoptile. These sheaths protect the delicate growing points as the seedling emerges from the soil during the germination process.

55. (A) Both A and R are true and R is the correct explanation of A.
The Polygonum type is the most prevalent form of embryo sac development in flowering plants. It is described as monosporic because it develops from a single functional megaspore. Through three successive mitotic divisions, this megaspore produces an eight-nucleate structure that eventually organizes into seven distinct cells: three antipodals, two synergids, one egg cell, and one large central cell.

56. (A) Guide the entry of the pollen tube into the embryo sac.
The synergid cells, located at the micropylar end of the embryo sac, possess specialized cellular thickenings known as the filiform apparatus. These structures play a crucial role in the fertilization process by secreting chemical attractants. These chemicals guide the growing pollen tube toward the embryo sac, ensuring that the male gametes are delivered directly to the vicinity of the egg.

57. (C) Anemophily
Anemophily is the term used to describe pollination that occurs through the agency of wind. Plants that utilize this method typically produce large quantities of small, lightweight, and non-sticky pollen grains that can be easily carried by air currents. These flowers are often inconspicuous, lack nectar and fragrance, and possess large, feathery stigmas designed to trap airborne pollen grains efficiently.

58. (A) Brightly colored petals and the presence of nectaries.
Entomophily refers to pollination carried out by insects. Flowers adapted for this method often exhibit features that attract pollinators, such as brightly colored petals, strong fragrances, and nectaries that produce sugary nectar as a food reward. These flowers also produce sticky pollen grains and possess stigmas that easily capture pollen from the bodies of visiting insects during their feeding activities.

59. (D) Prevents the germination of pollen on the stigma of the same flower or plant.
Self-incompatibility is a genetic mechanism employed by many flowering plants to prevent self-fertilization and promote outcrossing. It involves a biochemical interaction between the pollen and the pistil tissue. If the pollen carries the same alleles as the pistil, its germination or pollen tube growth is inhibited. This ensures that only pollen from genetically different individuals can successfully complete fertilization.

60. (A) P-4, Q-3, R-2, S-1
Pollination can be facilitated by various biological and physical agencies, each with its own descriptive term. Entomophily refers to pollination by insects, while ornithophily is performed by birds. Hydrophily involves the transport of pollen through water, and chiropterophily is the specific term for pollination carried out by bats. These different mechanisms reflect the diverse evolutionary adaptations of flowering plants.

61. (C) Fusion of one male gamete with the egg and another with the central cell.
Double fertilization is a unique process in angiosperms involving two separate fusion events. One male gamete fuses with the haploid egg cell to form a diploid zygote, a process called syngamy. Simultaneously, the second male gamete fuses with the two polar nuclei in the central cell, resulting in the formation of a triploid primary endosperm nucleus through a process known as triple fusion.

62. (D) Primary Endosperm Nucleus (PEN)
Triple fusion is one of the two fertilization events that occur in angiosperms. It involves the fusion of a second male gamete with the two polar nuclei located within the large central cell of the embryo sac. This fusion of three haploid nuclei results in the formation of a triploid primary endosperm nucleus, which eventually develops into the nutritive endosperm tissue.

63. (A) Triploid (3n)
The primary endosperm nucleus (PEN) is formed through the fusion of three haploid nuclei: one male gamete and two polar nuclei from the central cell. Consequently, the resulting tissue is triploid, containing three sets of chromosomes. This triploid nature is a characteristic feature of the endosperm in most angiosperms, providing a specialized nutritive environment for the developing embryo within the seed.

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(B) Simple fleshy
(C) Dry indehiscent
(D) Aggregate

291. Which of the following is an example of a seed with perisperm?
(A) Pea
(B) Bean
(C) Black pepper
(D) Groundnut

292. In artificial hybridization, the process of bagging the emasculated flower is done to:
(A) Attract pollinators.
(B) Induce fruit development.
(C) Speed up the maturation of the stigma.
(D) Prevent contamination from unwanted pollen.

293. The vascular cambium in a dicot root is completely secondary in origin. This statement is:
(A) True, as it originates entirely from the pericycle.
(B) False, as it is a primary meristem.
(C) False, as it originates partly from the conjunctive tissue and partly from the pericycle.
(D) True, as it originates entirely from the endodermis.

294. The heartwood cannot conduct water because its:
(A) Parenchyma cells are actively dividing.
(B) Tracheary elements are filled with tyloses and depositions of organic compounds.
(C) Sieve tubes are blocked.
(D) Cells are thin-walled and delicate.

295. Which type of phyllotaxy is seen in Calotropis?
(A) Alternate
(B) Whorled
(C) Spiral
(D) Opposite decussate

296. The transfer of pollen from the anther to the stigma is called:
(A) Pollination
(B) Fertilization
(C) Germination
(D) Diffusion

297. The embryo sac known as the Polygonum type is:
(A) Bisporic and 8-nucleate
(B) Tetrasporic and 16-nucleate
(C) Monosporic and 8-nucleate
(D) Monosporic and 4-nucleate

298. In a dicot embryo, the portion of the embryonal axis below the level of the cotyledons is the:
(A) Hypocotyl
(B) Epicotyl
(C) Coleoptile
(D) Plumule

299. A 'cypsela' is a single-seeded dry fruit that develops from a bicarpellary, syncarpous, inferior ovary. Which family is it characteristic of?
(A) Fabaceae
(B) Solanaceae
(C) Poaceae
(D) Asteraceae

300. The propagation of sugarcane is typically done by using:
(A) Seeds
(B) Stem cuttings (setts)
(C) Root cuttings
(D) Leaf buds

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73. (C) False fruit or pseudocarp
A true fruit develops solely from the ovary after fertilization. However, in some plants, other floral parts such as the thalamus, receptacle, or calyx also contribute to the formation of the fruit. These are known as false fruits or pseudocarps. Familiar examples include apples and strawberries, where the fleshy, edible portion is derived from the thalamus rather than the ovary wall.

74. (A) Pericarp
The pericarp is the wall of the fruit that develops directly from the wall of the ovary after fertilization. It serves to protect the seeds and often aids in their dispersal. In many fleshy fruits, the pericarp is further differentiated into three distinct layers: the outer epicarp, the middle mesocarp, and the inner endocarp, each of which may have different textures.

75. (D) Multicarpellary, apocarpous gynoecium
An aggregate fruit is formed from a single flower that possesses multiple, separate carpels, a condition known as a multicarpellary, apocarpous gynoecium. Each individual carpel develops into a small fruitlet, and these fruitlets together form a single collective fruit. Examples include raspberries and strawberries, where many small achenes or drupelets are clustered together on a common receptacle or floral base.

76. (B) An entire inflorescence
Multiple or composite fruits develop from an entire inflorescence rather than from a single flower. In plants like pineapple, fig, and mulberry, the ovaries of several closely packed flowers, along with other floral and stalk tissues, fuse together during maturation to form a single, large fruit-like structure. This complex development allows for the efficient packaging and dispersal of numerous seeds simultaneously.

77. (C) Being developed without the process of fertilization.
Parthenocarpy is the process by which fruits develop without the fertilization of ovules. As a result, these fruits are typically seedless. This phenomenon can occur naturally in some species like bananas or can be induced through the application of plant growth hormones. Parthenocarpic fruits are often highly valued in agriculture because they provide a seedless consumer experience for various commercial crops.

78. (D) Endocarp is hard and stony.
A drupe is a type of fleshy fruit, often called a stone fruit, characterized by a specific three-layered pericarp. It has a thin outer epicarp, a fleshy or fibrous middle mesocarp, and a hard, stony inner endocarp that encloses the seed. Common examples of drupes include mangoes, cherries, and peaches, where the stony layer provides significant protection to the internal developing seed.

79. (A) Ovule
A seed is the final product of sexual reproduction in flowering plants, representing a fertilized and matured ovule. It contains an embryo, which is the young plant, along with stored nutrients in the form of endosperm or cotyledons, all enclosed within a protective seed coat. The transition from ovule to seed involves complex physiological and structural changes triggered by the fertilization process.

80. (A) Both A and R are true and R is the correct explanation of A.
In most seeds, the nucellus is completely consumed during the development of the embryo sac or endosperm. However, in some species like black pepper and beet, a portion of the nucellus persists in the mature seed. This persistent, nutritive tissue is known as the perisperm. It functions as an additional source of food reserves for the embryo during the germination process.

81. (B) The endosperm is completely consumed by the developing embryo.
Seeds are classified as albuminous or non-albuminous based on the presence of endosperm at maturity. Non-albuminous or exalbuminous seeds are those in which the endosperm is entirely consumed by the developing embryo during its growth. In these seeds, such as peas and beans, the food reserves are typically stored within the cotyledons rather than in a separate endosperm tissue.

82. (A) Helps the species to survive through unfavorable conditions.
Seed dormancy is a state of suspended animation where seeds do not germinate even

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genes remain active. In the absence of C, A-class activity expands to all whorls. Consequently, every whorl of the flower will develop as sepals, resulting in a flower consisting entirely of sepals.

120. (A) Sporopollenin
The outer layer of a pollen grain, known as the exine, is composed of sporopollenin, one of the most resistant organic materials found in nature. It can withstand high temperatures, strong acids, and powerful alkalis, and no known enzyme can degrade it. This durability protects the delicate male gametophyte during dispersal and allows pollen to persist for long periods in the fossil record.

121. (C) Anatropous
Anatropous is the most common type of ovule in angiosperms, occurring in over eighty percent of flowering plant families. It is characterized by being completely inverted, where the body of the ovule rotates one hundred eighty degrees during development. This brings the micropyle close to the funicle, facilitating the entry of the pollen tube during the fertilization process in many different species.

122. (A) Apospory
Apospory is a form of apomixis where an embryo sac develops directly from a diploid somatic cell of the ovule, such as a nucellar cell, without undergoing meiosis. The resulting embryo sac and the embryo that develops from the egg cell are genetically identical to the parent plant. This process bypasses the normal sexual cycle, allowing for the asexual production of seeds.

123. (D) The differential timing of maturation of the anther and stigma.
Dichogamy is a common mechanism used by hermaphroditic flowers to avoid self-pollination. It involves the maturation of the male and female reproductive organs at different times. If the anthers mature first, it is called protandry; if the stigma becomes receptive first, it is protogyny. This temporal separation ensures that the flower's own pollen is not available when its stigma is receptive.

124. (B) Syngamy
Syngamy is the specific fertilization event in angiosperms where one of the two male gametes fuses with the haploid egg cell. This fusion results in the formation of a diploid zygote, which eventually develops into the embryo. Together with triple fusion, syngamy constitutes the process of double fertilization, a defining characteristic of the life cycle of all flowering plant species.

125. (B) P-3, Q-1, R-2
Endosperm development follows three main patterns. In nuclear development, repeated free nuclear divisions occur before any cell walls form. In cellular development, every nuclear division is immediately followed by the formation of a cell wall. Helobial development is an intermediate type where the first division produces two chambers, followed by free nuclear divisions specifically within the larger micropylar chamber of the cell.

126. (D) Coleoptile and coleorhiza
Monocot embryos, particularly in the grass family, possess specialized protective structures. The single cotyledon is called the scutellum. The embryonal axis is enclosed by two sheaths: the coleoptile, which covers and protects the young shoot or plumule, and the coleorhiza, which protects the embryonic root or radicle. these structures are essential for protecting the delicate tissues as the seedling emerges from the soil.

127. (A) Pome - Apple
Fruits are classified based on their development and structure. A pome is a false fruit where the fleshy part is derived from the thalamus, with the apple being a classic example. A berry, like a tomato, is a fleshy fruit with many seeds. A drupe, like a mango, has a stony endocarp. A legume, like a pea, is a dry dehiscent fruit.

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128. (B) Endosperm
Albuminous seeds, also known as endospermic seeds, are those that retain a significant amount of endosperm tissue even after the embryo has fully matured. In these seeds, such as castor, maize, and wheat, the embryo does not completely consume the endosperm during its development. The remaining endosperm then serves as a critical food reservoir for the young seedling during the process of germination.

along with a larger and more prominent central pith.

92. (B) Parasitic plants
Haustoria, also known as sucking roots, are specialized root modifications found in parasitic plants like Cuscuta. These structures penetrate the tissues of a host plant to establish a connection with its vascular system. This allows the parasite to absorb water, minerals, and organic nutrients directly from the host. This adaptation is essential for the survival of plants that cannot perform sufficient photosynthesis.

93. (A) Both Statement I and Statement II are true.
The vascular cambium is composed of two types of meristematic cells. Fusiform initials are elongated cells that divide to produce the vertical or axial system of the secondary xylem and phloem. Ray initials are smaller, more isodiametric cells that divide to form the radial system, also known as vascular rays, which facilitate the horizontal transport of water and nutrients within the stem.

94. (D) All tissues outside the secondary xylem.
In a botanical context, the term bark refers to all the tissues located exterior to the vascular cambium. This includes the secondary phloem, the cortex, and the periderm, which consists of the phellogen, phellem, and phelloderm. While the periderm provides the outermost protective layer, the secondary phloem is also considered part of the bark, contributing to its overall thickness and protective function.

95. (A) P-2, Q-1, R-4, S-3
Distinct anatomical features are used to identify different plant groups. A polyarch xylem arrangement is characteristic of monocot roots, while vascular bundles arranged in a ring are found in dicot stems. Bulliform cells are a specific feature of many monocot leaves, helping them roll. Sunken stomata are a classic adaptation found in xerophytes to reduce water loss in arid environmental conditions.

96. (B) Opposite decussate
Opposite decussate is a specific pattern of phyllotaxy where two leaves arise at each node on opposite sides of the stem. Each successive pair of leaves is oriented at a right angle to the pair above and below it. This arrangement, commonly seen in plants like Calotropis and guava, optimizes the distribution of leaves to maximize sunlight exposure while minimizing shading between layers.

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97. (B) Forces water and solutes to pass through the cell membrane, regulating uptake.
Casparian strips are specialized bands of suberin and sometimes lignin found in the endodermal cell walls of roots. These impermeable barriers block the apoplastic movement of water and dissolved minerals through the cell walls. This forces all substances to cross the selectively permeable plasma membrane, allowing the plant to exert physiological control over the types and amounts of solutes entering the stele.

98. (A) Large central vacuole and ergastic substances.
Meristematic cells are characterized by their high metabolic rate and continuous cell division. They typically possess dense cytoplasm, a prominent nucleus, and thin cellulosic cell walls. Unlike mature permanent cells, meristematic cells usually have very small vacuoles or none at all, and they lack ergastic substances like starch grains or crystals, which are more commonly found in differentiated tissues for storage.

99. (C) Closest to the apical meristem.
In the shoot apex, leaf development follows an acropetal sequence, meaning the youngest organs are found at the tip. The most recently formed leaf primordium is always located closest to the shoot apical meristem. As the apex continues to grow upward, older leaves are left further down the stem. This organization ensures a continuous supply of new leaves for the growing plant body.

100. (D) I, II, and III
Anomalous secondary growth involves deviations from the standard secondary thickening seen in most dicots. This includes the formation of furrowed xylem, as observed in Bignonia, and the development of successive cambial rings. Furthermore, while most monocots lack secondary growth, some species like Dracaena exhibit an anomalous type produced by a specialized cambium in the ground tissue, making all three statements correct.

shoots and roots. This growth is driven by the activity of apical meristems, which produce new cells that eventually differentiate into primary tissues. This process allows the plant to extend its roots deeper into the soil and its shoots higher into the air to maximize resource capture.

157. (C) It is protected by a root cap.
The shoot apical meristem is a terminal, dome-shaped region responsible for the primary growth of the shoot and the formation of leaves and axillary buds. It is organized into distinct cellular zones, such as the central and peripheral zones. Unlike the root apical meristem, which is covered by a protective root cap, the shoot apex is typically protected by young developing leaf primordia.

158. (D) Amaranthus and Boerhaavia
Medullary bundles are vascular bundles that are found within the pith of a stem, which is an unusual position. This is considered a primary anomalous structure because it is established during the initial development of the plant. Such arrangements are characteristic features of certain plant groups, including members of the Amaranthaceae and Nyctaginaceae families, such as the genera Amaranthus and Boerhaavia.

159. (A) Venation
Venation is the term used to describe the arrangement of veins and smaller veinlets within the lamina, or blade, of a leaf. These vascular structures provide mechanical support and serve as the transport system for water, minerals, and nutrients. There are two main types: reticulate venation, common in dicots, where veins form a network, and parallel venation, common in monocots, where veins run alongside.

160. (B) Photoperiod (day length)
For many plants, the transition from vegetative growth to flowering is triggered by specific environmental signals. The most critical of these is the photoperiod, or the relative length of day and night. Plants perceive this signal through their leaves using specialized pigment proteins. This ensures that flowering occurs during a specific season when environmental conditions and pollinator availability are likely to be optimal for reproduction.

161. (B) Two or three-celled
At the time of dispersal from the anther, the male gametophyte, or pollen grain, is typically in a two-celled or three-celled state. In most angiosperms, it consists of a large vegetative cell and a smaller generative cell. In some species, the generative cell divides before shedding to form two male gametes, resulting in a three-celled pollen grain at the time of its release.

162. (A) Chalaza
The chalaza is the basal region of the ovule where the integuments and the nucellus are joined. It is located at the opposite end of the micropyle. The chalaza plays an important role in the structural organization of the ovule and serves as the entry point for nutrients delivered through the funicle's vascular supply, supporting the development of the female gametophyte and the embryo.

163. (C) Generally considered to be nutritive, though they often degenerate rapidly.
Antipodal cells are a group of three haploid cells located at the chalazal end of the mature embryo sac. While their exact function is not always clear in all species, they are generally thought to play a role in providing nutrition to the developing embryo sac. In many angiosperms, these cells are short-lived and typically begin to degenerate either before or shortly after the process of fertilization.

164. (D) Remain closed, ensuring self-pollination.
Cleistogamous flowers are a specialized type of flower that never opens, even at maturity. Because the reproductive organs are entirely enclosed within the floral envelope, self-pollination is guaranteed. This strategy ensures seed production even in the absence of pollinators or under unfavorable environmental conditions. Some plants produce both typical open flowers and cleistogamous flowers as a way to balance genetic diversity and reproductive certainty.

165. (D) I, II, and III
Following successful double fertilization, a series of coordinated developmental changes occurs within the flower. The ovary matures into the fruit, which serves to protect and disperse the seeds. The ovules within the ovary develop into seeds, each containing a new plant. Simultaneously, the diploid zygote undergoes repeated cell divisions

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plants are joined together. The "scion" provides the desired shoot characteristics, such as fruit quality, while the "stock" provides a robust root system adapted to the soil. This allows horticulturists to combine the best traits of both plants into a single individual, ensuring consistent and high-quality crop production.

111. (A) Function
Meristems can be classified in various ways, including by their function in producing different tissue systems. The protoderm is the outer meristematic layer that eventually forms the dermal tissue system. The procambium gives rise to the vascular tissue system, including xylem and phloem. The ground meristem produces the ground tissue system, which includes tissues like the cortex, pith, and mesophyll in various organs.

112. (B) Napiform root - Carrot
Taproot modifications for food storage are classified based on their shape. A conical root, like that of a carrot, is wide at the top and tapers toward the bottom. A napiform root, such as a turnip or beet, is very swollen at the top and tapers abruptly at the base. A fusiform root, like a radish, is widest in the middle and tapers at both ends.

113. (B) Only gives rise to lateral roots.
In both dicot and monocot roots, the pericycle is involved in the formation of lateral roots. However, in dicot roots, the pericycle also plays a crucial role in secondary growth by contributing to the formation of the vascular cambium and the cork cambium. Since most monocot roots do not undergo secondary growth, the function of their pericycle is typically restricted to producing lateral roots.

114. (A) The origin of the vascular cambium.
A major difference in secondary growth between dicot stems and roots is the origin of the vascular cambium. In stems, it is partly primary (intrafascicular) and partly secondary (interfascicular). In roots, the entire vascular cambium is secondary in origin, developing from the conjunctive tissue located below the phloem bundles and from the portions of the pericycle tissue located outside of the protoxylem.

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115. (C) Phylloclades
Phylloclades are specialized stem modifications found in plants like Opuntia. These stems become flattened, green, and fleshy, allowing them to perform photosynthesis in place of leaves, which are often reduced to spines to minimize water loss. Phylloclades have multiple nodes and internodes and are a key adaptation for survival in arid or desert environments where water conservation is absolutely critical.

116. (D) Leptadenia and Salvadora
Included phloem, also known as interxylary phloem, is an anatomical anomaly where strands of phloem tissue become embedded within the secondary xylem. This occurs during secondary growth when the cambium occasionally produces phloem toward the inside instead of xylem. This feature is a characteristic form of anomalous secondary growth found in the stems of certain plants, such as Leptadenia, Salvadora, and Chenopodium.

117. (A) Both Statement I and Statement II are true.
Leaf orientation and anatomy vary between plant groups. Isobilateral leaves, common in monocots like grasses, are typically oriented vertically and have similar internal structures on both sides. Dorsiventral leaves, characteristic of dicots, are usually oriented horizontally, showing a clear distinction between the upper and lower surfaces, with specialized tissue layers like palisade parenchyma optimized for capturing sunlight on the top side.

118. (B) A permanent change marking the end of vegetative growth at that apex.
The transition of a vegetative apical meristem to a floral meristem is a significant developmental milestone in a plant's life. This change is typically irreversible and marks the termination of vegetative growth at that specific shoot tip. Once the floral meristem is formed, it follows a determinate growth pattern, producing floral organs and eventually seeds, effectively concluding the growing activity of that apex.

119. (D) Only sepals
According to the ABC model, A-class genes alone specify sepals, A and B specify petals, B and C specify stamens, and C alone specifies carpels. If both B and C function are lost, only A-class

under favorable conditions. This physiological mechanism is crucial for plant survival, as it prevents seeds from sprouting during periods that might be followed by harsh environmental conditions, such as winter or drought. Dormancy ensures that germination occurs only when the chances of seedling survival and successful growth are maximized.

83. (C) Pappus and winged extensions
Plants have evolved various structural adaptations to facilitate the dispersal of seeds by wind, a process known as anemochory. Some seeds or fruits possess lightweight, wing-like extensions that increase surface area, while others, like dandelions, have a tuft of hairs called a pappus. These modifications allow the seeds to remain airborne for longer periods, enabling them to be carried across vast distances.

84. (D) Asexual reproduction
Vegetative propagation is a form of asexual reproduction where new plants are produced from vegetative parts such as roots, stems, or leaves, without the involvement of seeds or spores. Since this process involves only mitotic cell divisions, the offspring are genetically identical to the parent plant, essentially acting as clones. This method is widely used in both natural environments and commercial agriculture.

85. (C) Tubers (eyes)
The potato plant utilizes specialized underground stem modifications called tubers for vegetative propagation. These tubers possess small depressions known as "eyes," which are actually axillary buds. When a piece of a tuber containing at least one eye is planted in suitable soil, the buds sprout and develop into a new plant. This allows for the rapid and efficient multiplication of potato crops.

86. (B) Leaf notches
Bryophyllum is a unique plant known for its ability to propagate vegetatively through its leaves. Small, adventurous buds develop along the notches present on the leaf margins. When these leaves fall onto moist soil or the buds detach, they grow into independent new plants. This specialized adaptation allows the plant to reproduce and spread quickly without relying solely on the production of seeds.

87. (D) All of the above
Natural vegetative propagation can occur through various specialized stem structures. Stolons in strawberries are horizontal stems that root at the nodes to form new plants. Rhizomes in ginger are fleshy underground stems that grow horizontally and produce new shoots. Corms in Colocasia are thickened, vertical underground stems that store food and generate new plants. All these examples represent effective asexual reproduction strategies.

88. (A) III, I, II, IV
The life cycle of an angiosperm follows a specific chronological sequence of events. First, microsporogenesis occurs within the anther to produce pollen grains. This is followed by pollination, where pollen is transferred to the stigma. Double fertilization then takes place within the embryo sac, leading finally to the development of the seed, which contains the embryo and necessary nutritive tissues.

89. (C) Root apical meristem
The quiescent center is a specific region located within the root apical meristem. It consists of a group of cells that divide at a much lower rate than the surrounding meristematic cells. This center serves as a reservoir of genetically stable cells that can replace damaged initials in the meristem, ensuring the long-term maintenance and proper organized growth of the root system.

90. (A) Pericycle
In dicot roots, lateral roots do not originate from the epidermis but instead arise from deep within the internal tissues. Specifically, they develop from the pericycle, which is the outermost layer of the vascular cylinder. This endogenous origin involves the activation of pericycle cells to divide and form a new root primordium, which then pushes through the cortex and epidermis to emerge.

91. (D) Number of xylem and phloem groups.
The primary anatomical difference in the stele of dicot and monocot roots lies in the organization of vascular tissues. Dicot roots typically have a limited number of xylem and phloem groups, usually ranging from two to four. In contrast, monocot roots are polyarch, meaning they possess many more vascular bundles, often exceeding six,

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129. (B) Providing a method for perennation, dispersal, and protection of the embryo.
Seeds play a vital role in the survival and spread of flowering plants. They protect the delicate embryo within a tough seed coat and often contain food reserves to support early growth. Additionally, seeds are adapted for dispersal to new habitats and can remain dormant for long periods, allowing the plant to survive through unfavorable environmental conditions until better circumstances for growth arise.

130. (D) I, II, and III
Artificial vegetative propagation involves human intervention to multiply plants using their vegetative parts. Common methods include taking cuttings of stems or roots, layering where roots are induced on a stem still attached to the parent, and grafting where tissues of two different plants are joined. These techniques are widely used in horticulture and agriculture to produce large numbers of genetically identical plants.

131. (C) Apical meristem
Apical meristems are located at the tips of roots and shoots and are responsible for the primary growth of the plant. These meristems produce the primary meristematic tissues—protoderm, ground meristem, and procambium—which then differentiate into the primary permanent tissues of the plant body. This process increases the length of the plant and establishes the basic tissue systems of the organism.

132. (D) Epidermis, cortex, and vascular tissue respectively.
The histogen theory proposes that the apical meristem is organized into three distinct layers called histogens. The outermost layer, the dermatogen, gives rise to the epidermis. The middle layer, the periblem, develops into the cortex. The innermost layer, the plerome, produces the central cylinder, which includes the vascular tissues and the pith. This theory provides a framework for understanding the origin of primary tissues.

133. (C) Fibrous root system
In many plants, particularly monocotyledons, the primary root is short-lived and does not persist as the main anchorage. Instead, it is replaced by a large cluster of thin, moderately branching roots that originate from the base of the stem. This arrangement is known as a fibrous root system, which provides extensive surface area for absorption and firm attachment to the soil for the plant.

134. (B) Conjunctive tissue
In the primary structure of a dicot root, the vascular bundles are arranged in a radial pattern. The tissue that occupies the space between the xylem and phloem bundles is known as conjunctive tissue. It typically consists of parenchymatous cells. During secondary growth, some of these conjunctive cells become meristematic and contribute to the formation of the vascular cambium, producing secondary vascular tissues.

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135. (D) Open
A vascular bundle is described as open when it contains a layer of meristematic tissue, the vascular cambium, between the xylem and phloem. This cambium has the potential to produce secondary xylem and phloem, allowing the stem or root to increase in girth. Open vascular bundles are characteristic of dicotyledonous plants and gymnosperms, facilitating their capacity for significant secondary growth over time.

136. (A) Sapwood (alburnum)
Sapwood, also known as alburnum, is the outer, lighter-colored region of the secondary xylem in a tree trunk. Unlike the central heartwood, sapwood is physiologically active and is responsible for the conduction of water and dissolved minerals from the roots to the leaves. It also serves as a site for food storage. Over time, the inner layers of sapwood gradually transform into heartwood.

137. (C) Gaseous exchange
Lenticels are specialized lens-shaped pores that develop in the periderm of woody stems and roots during secondary growth. They consist of loosely arranged cells with large intercellular spaces. These structures provide a pathway for the exchange of gases, such as oxygen and carbon dioxide, between the internal tissues of the plant and the external atmosphere, bypassing the impermeable cork layer of the bark.

138. (A) Bicollateral
A bicollateral vascular bundle is a specialized arrangement where phloem tissue is found on both the outer and inner sides of the xylem. These two phloem regions are referred to as outer and inner phloem, respectively. Such bundles are always open, as a layer of cambium is typically present between the xylem and the outer phloem. This arrangement is commonly seen in certain plant families.

139. (D) Photosynthesis
In a typical dicot leaf, the mesophyll is differentiated into two layers. The palisade parenchyma consists of vertically elongated, closely packed cells located just below the upper epidermis. These cells are rich in chloroplasts, making the palisade layer the primary site for photosynthesis. Its position and organized structure allow for the maximum absorption of sunlight as it penetrates the upper surface of the leaf.

140. (A) Both A and R are true and R is the correct explanation of A.
Aquatic plants often exhibit highly dissected or ribbon-like leaves as an adaptation to their environment. This morphology significantly reduces the physical resistance offered to moving water currents, preventing the leaves from being torn. Furthermore, the increased surface-area-to-volume ratio facilitates the efficient absorption of dissolved gases and nutrients directly from the surrounding water, which is essential for the survival of submerged plants.

141. (C) Stamens
The ABC model of flower development defines organ identity based on gene expression patterns. The third whorl of a flower is specified by the combined activity of B-class and C-class genes. When both of these gene classes are active together in the same region, the meristematic cells are programmed to develop into stamens, which are the male reproductive organs of the flowering plant.

142. (D) 2n
The microspore mother cell, also known as the pollen mother cell, is a specialized diploid cell found within the microsporangium of the anther. Since it is part of the sporophytic generation of the plant, it contains two full sets of chromosomes, represented as 2n. This cell eventually undergoes meiosis to produce four haploid microspores, which marks the beginning of the gametophytic generation.

143. (A) Campylotropous
A campylotropous ovule is characterized by a distinct curvature in its body. This growth pattern causes the micropyle and chalaza to no longer lie in a straight line. However, unlike some other curved types, the embryo sac within the campylotropous ovule remains relatively straight. This orientation brings the micropyle closer to the funicle, which can influence the path taken by the growing pollen tube.

144. (B) All four megaspore nuclei
A tetrasporic embryo sac is a type of female gametophyte that develops when all four haploid nuclei produced during meiosis participate in its formation. In this case, cytokinesis does not occur after either meiotic division, resulting in a single cell containing four nuclei. These four nuclei then undergo further mitotic divisions to form a mature embryo sac, such as the sixteen-nucleate Peperomia type.

145. (B) Mucilaginous covering
Plants that utilize water for pollination, a process called hydrophily, have evolved specific adaptations to protect their reproductive structures. The pollen grains of many aquatic species are often covered by a protective mucilaginous layer. This coating prevents the pollen from becoming waterlogged or damaged by wetting, ensuring that it remains buoyant and viable as it travels through the water to reach a receptive stigma.

146. (A) One male gamete (n) and two polar nuclei (n+n).
Triple fusion is a unique process in angiosperm reproduction where a second male gamete fuses with the two polar nuclei located in the central cell of the embryo sac. Since all three participating nuclei are haploid, their fusion results in a single triploid nucleus. This primary endosperm nucleus eventually divides to form the endosperm, a specialized tissue that provides nutrition to the developing embryo.

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147. (C) Uneven and irregular surface due to ingrowths of the seed coat.
Ruminate endosperm is characterized by a distinctly mottled, uneven, or irregular appearance in a cross-section of a seed. This texture is caused by the inward folding or irregular growth of the seed coat, or sometimes the nucellus, into the endosperm tissue. This feature is commonly found in certain plant families, such as the Annonaceae and Arecaceae, including the seeds of the betel nut.

148. (D) Epicotyl
In a developing dicot embryo, the embryonal axis is divided into regions relative to the point of attachment of the cotyledons. The portion of the axis located above the level of the cotyledons is known as the epicotyl. The epicotyl terminates in the plumule, which is the embryonic shoot. Growth of the epicotyl during germination results in the shoot being pushed above the ground.

149. (C) Pome
A pome is a type of fleshy false fruit characteristic of certain members of the Rosaceae family, such as apples and pears. It develops from an inferior, multicarpellary ovary. The unique feature of a pome is that the edible, fleshy portion is primarily derived from the enlarged thalamus or floral tube that surrounds the ovary, while the true fruit wall forms the central core.

150. (B) Hilum
The hilum is a prominent scar visible on the seed coat of a mature seed. It represents the point where the ovule was originally attached to the funicle, the stalk that connected it to the placenta within the ovary. Near the hilum, a small pore called the micropyle is often visible, which facilitates the entry of water and oxygen during the process of seed germination.

151. (D) Meiosis and syngamy
Apomixis is a specialized form of asexual reproduction where seeds are produced without the normal processes of meiosis and fertilization, also known as syngamy. Despite the lack of sexual fusion, the resulting seeds contain an embryo that is genetically identical to the parent plant. This mechanism allows certain plants to produce clones of themselves through seeds, combining the benefits of asexual reproduction with seed dispersal.

152. (A) A horizontal branch with long internodes that roots at the nodes.
A runner is a sub-aerial stem modification used for vegetative propagation. It consists of a slender, horizontal branch that grows along the soil surface. At each node, the runner produces adventitious roots and new upright shoots. As the runner continues to grow, it can form a series of interconnected daughter plants. If the runner breaks, these daughter plants become independent individuals, spreading the species.

153. (C) Secondary meristem
Secondary meristems are those that develop later in a plant's life from primary permanent tissues that have already differentiated. This process is called dedifferentiation. These meristems, such as the vascular cambium in roots and the cork cambium, are primarily responsible for secondary growth, which increases the thickness or girth of the plant body by producing secondary tissues like wood and cork.

154. (A) Endodermis
Casparian strips are specialized bands of waterproof, suberized material found in the endodermis of roots. These strips are located in the radial and tangential walls of the endodermal cells. By blocking the movement of water through the cell walls, they force all water and solutes to pass through the selectively permeable plasma membrane, allowing the plant to regulate the internal nutrient environment.

155. (B) P-3, Q-2, R-4, S-1
Different tissues in woody plants have specialized roles. Heartwood provides mechanical support but no longer conducts water. Sapwood is the active layer for water conduction. The vascular cambium is responsible for producing secondary xylem and phloem, leading to increased girth. The cork cambium, or phellogen, produces the periderm, which serves as a protective outer covering that replaces the epidermis during secondary growth.

156. (B) Primary growth
Primary growth refers to the increase in the length of a plant's axis, occurring at the tips of

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101. (C) Conjoint, collateral, and closed
The vascular bundles in a dicot leaf are typically conjoint, meaning xylem and phloem are on the same radius, and collateral, with phloem located toward the outside. These bundles are described as closed because they lack a persistent vascular cambium, which prevents further secondary growth within the leaf. These bundles are often surrounded by a parenchymatous bundle sheath that regulates transport.

102. (B) Stamens and Carpels
In the ABC model of floral development in Arabidopsis, the C-class genes play a crucial role in determining the identity of the reproductive organs. When C-class genes are expressed in combination with B-class genes in the third whorl, they specify the development of stamens. When C-class genes act alone in the fourth, innermost whorl, they specify the development of the carpels.

103. (D) Meiosis
Both microsporogenesis and megasporogenesis are essential processes in the plant life cycle that involve the reduction of chromosome numbers. In both cases, a diploid mother cell—the microspore mother cell or the megaspore mother cell—undergoes meiosis to produce four haploid spores. This ensures that the resulting gametophytes and gametes contain only one set of chromosomes, maintaining the species' ploidy level after fertilization.

104. (A) Two megaspore nuclei from the megaspore tetrad.
A bisporic embryo sac is a type of female gametophyte development where two of the four megaspore nuclei produced during meiosis contribute to its formation. After the first meiotic division, cytokinesis occurs, but it does not follow the second meiotic division. This results in two dyad cells, one of which eventually develops into an eight-nucleate embryo sac, characteristic of plants like Allium.

105. (C) Cross-pollination between flowers of two different plants.
Allogamy, often used interchangeably with cross-pollination, is the transfer of pollen from the anther of a flower on one plant to the stigma of a flower on a genetically different plant of the same species. This process increases genetic diversity within the population by combining different alleles. It is often facilitated by external agencies such as wind, water, insects, or other animals.

106. (A) The genotype of the pollen grain itself.
Gametophytic self-incompatibility is a biochemical mechanism where the success of pollination is determined by the haploid genotype of the pollen grain. If the S-allele in the pollen matches either of the S-alleles in the diploid tissue of the pistil, the pollen tube growth is inhibited. This prevents self-fertilization by ensuring that only pollen with a different genetic makeup can successfully complete the fertilization process.

107. (D) Provide nutrition to the developing embryo.
The endosperm is a specialized nutritive tissue that forms as a result of double fertilization in angiosperms. Its primary role is to accumulate food reserves, such as starch, proteins, and oils, which are then utilized by the developing embryo during its growth and during the initial stages of seed germination. This ensures the young seedling has sufficient energy before it can perform photosynthesis.

108. (B) Push the embryo deep into the endosperm.
During the development of a dicot embryo, the basal cell divides to form a linear chain of cells called the suspensor. The primary function of the suspensor is to act as a supportive structure that physically pushes the developing proembryo deep into the nutritive endosperm tissue. This ensures that the young embryo has maximum access to the food reserves required for its continued growth.

109. (C) Legume (pea pod)
A legume, such as a pea pod, is a classic example of a simple, dry dehiscent fruit. It develops from a monocarpellary ovary and, upon reaching maturity, the dry pericarp splits open along both the dorsal and ventral sutures to release the seeds. This dehiscence mechanism is a critical adaptation for seed dispersal in many members of the Fabaceae family.

110. (A) Both A and R are true and R is the correct explanation of A.
Grafting is an artificial vegetative propagation technique where the tissues of two different

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and differentiation to form the embryo, the next generation's sporophyte.

166. (B) Pea
Non-albuminous or exalbuminous seeds are those where the endosperm is completely consumed by the developing embryo before the seed reaches maturity. In such seeds, the food reserves are typically transferred to and stored within the cotyledons. The pea is a classic example of this type of seed. Consequently, when the seed is mature, the embryo is the dominant structure and endosperm is absent.

167. (D) The basal cell playing a minor role or forming a small suspensor.
The Onagraceae type of embryo development is characterized by a specific pattern of early cell divisions. In this type, the first division of the zygote is transverse, producing an apical cell and a basal cell. Most of the embryo proper is derived from the apical cell, while the basal cell contributes very little to the final structure, typically forming only a small, simple suspensor.

168. (A) Splits into single-seeded parts (mericarps) at maturity.
A schizocarpic fruit is a specialized type of dry fruit that, upon reaching maturity, breaks apart into several single-seeded units known as mericarps. Unlike dehiscent fruits, these mericarps do not typically open to release the seed immediately. This mechanism allows for the dispersal of individual seeds while still protected by a portion of the fruit wall, representing an intermediate strategy between dehiscence and indehiscence.

169. (C) It preserves the genetic traits of the parent plant.
Vegetative propagation is highly valued in horticulture because it is a form of asexual reproduction that produces offspring genetically identical to the parent. This allows growers to maintain and multiply specific desirable traits, such as fruit quality, flower color, or disease resistance, without the genetic variation and uncertainty associated with sexual reproduction through seeds. This ensures a consistent and high-quality product for commercial use.

170. (A) Mint and Chrysanthemum
A sucker is a type of vegetative propagule that originates from an underground portion of the stem. It grows horizontally for some distance beneath the soil before turning upward to emerge as a new leafy shoot. Suckers eventually develop their own roots and can become independent plants. Common examples of plants that naturally reproduce using suckers include mint, chrysanthemum, pineapple, and banana.

171. (D) Clowes
The quiescent center theory was proposed by F.A.L. Clowes to describe a specific organizational feature of the root apical meristem. Based on autoradiographic studies, he identified a central region of cells that divide very infrequently compared to the surrounding meristematic tissue. This theory highlights the role of these cells as a genetically stable reserve that can regenerate the active parts of the meristem.

172. (B) Monocot root
Monocot roots can be distinguished from dicot roots by the organization of their vascular tissues. They possess a polyarch arrangement, meaning there are many alternating groups of xylem and phloem, typically more than six. The xylem development is exarch, and the vascular bundles are arranged radially around a large, well-developed central pith. This complex structure provides both efficient transport and mechanical stability.

173. (C) Pothos (money plant) and Ivy
Climbing roots are a type of adventitious root modification designed to provide mechanical support to plants with weak stems. These roots emerge from the nodes or internodes of the stem and attach themselves to nearby surfaces or structures, such as walls or other trees. This allows the plant to grow upward toward the light. Common examples include the money plant and ivy.

174. (D) Parenchymatous rays for radial conduction and storage.
The vascular cambium contains ray initials, which are relatively small, isodiametric cells. These cells divide to produce the radial system of the secondary plant body, consisting of parenchymatous vascular rays. These rays extend

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in specific physiological contexts. Therefore, compared to anchorage and absorption, it is considered a less universal primary function of roots.

193. (B) Epidermis or cortex
Phellogen, also known as cork cambium, is a secondary meristem that arises during the process of secondary growth. It develops from permanent tissues that undergo dedifferentiation, typically starting in the epidermis or the outer layers of the cortex. The phellogen then divides to produce cork on the outside and secondary cortex on the inside, forming the protective periderm that replaces the epidermis.

194. (A) Both Statement I and Statement II are true.
The anatomical organization of a monocot stem is termed an atactostele, which is characterized by vascular bundles being scattered throughout the ground tissue. Because of this scattered arrangement, there is no clear boundary or differentiation between a central pith and an outer cortex. The entire region between the epidermis and the center of the stem consists of undifferentiated parenchymatous or sclerenchymatous ground tissue.

195. (C) Sessile
A leaf is described as sessile when it lacks a petiole, the stalk that typically attaches the leaf blade to the stem. In sessile leaves, the lamina is attached directly to the node of the stem. This arrangement is common in many monocots and some dicots. Sessile leaves may also exhibit a sheathing leaf base that partially or completely wraps around the stem.

196. (D) Generative cell
In angiosperms, the generative cell is one of the two cells produced by the first mitotic division of the microspore. As the pollen grain germinates and the pollen tube grows, the generative cell undergoes a second mitotic division to produce two haploid male gametes. These gametes are then delivered to the embryo sac to participate in the unique processes of syngamy and triple fusion.

197. (C) Monosporic, 4-nucleate
The Oenothera type is a specific variant of embryo sac development. It is described as monosporic because it develops from a single functional megaspore, typically the one at the micropylar end. Unlike the more common eight-nucleate Polygonum type, the functional megaspore in Oenothera undergoes only two mitotic divisions, resulting in a mature embryo sac that contains only four nuclei and lacks antipodal cells.

198. (B) Geitonogamy
Geitonogamy is a type of pollination where pollen is transferred from the anther of one flower to the stigma of another flower on the same plant. While it is functionally a form of cross-pollination because it involves a pollinating agent, it is genetically equivalent to self-pollination since all flowers on a single plant share the same genetic makeup and identical allelic combinations.

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199. (D) Fleshy aril
The edible part of a litchi fruit is not derived from the pericarp, but is instead a specialized structure called an aril. The aril is a fleshy, white, and translucent outgrowth that develops from the funicle and eventually surrounds the seed. This makes the litchi a unique type of fruit where the portion consumed by humans is an accessory structure rather than the true fruit wall.

200. (D) I, II, and III
A seed is a complex structure that develops from a matured ovule. The protective seed coat is formed from the original integuments of the ovule. The micropyle often remains as a tiny pore, allowing for water and air entry during germination. Internally, the seed contains the embryo, which consists of the embryonal axis and one or two cotyledons that store or absorb nutrients.

201. (C) Rapidly multiplying plant material in vitro to produce many progeny plants.
Micropropagation is a modern plant tissue culture technique used to rapidly multiply plant material under sterile, controlled laboratory conditions. By using small pieces of tissue, such as shoot tips or buds, thousands of genetically identical offspring, or clones, can be produced from a single parent plant in a short time. This method is extensively used for the large-scale commercial production of ornamental and crop plants.

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gamete with two polar nuclei. This process of triple fusion results in a triploid nutritive tissue, providing a more complex genetic environment for supporting the embryo's development.

184. (A) Genotype of the diploid sporophytic tissue of the plant that produced the pollen.
Sporophytic self-incompatibility is a mechanism where the rejection of pollen is determined by the diploid genotype of the parent plant that produced the pollen. The incompatibility proteins are deposited onto the pollen wall from the tapetum during development. If these proteins match the alleles in the stigma, the pollen fails to germinate, ensuring that the plant only successfully breeds with genetically compatible individuals.

185. (C) Multiple fruit
A multiple fruit, also known as a composite fruit, develops from an entire inflorescence where the ovaries of many flowers fuse together during maturation. While a multicarpellary, syncarpous gynoecium often forms a simple fruit, in certain developmental pathways where the entire reproductive structure of the cluster becomes a single unit, it is categorized as a multiple fruit according to specific botanical classification schemes.

186. (A) Polyembryony
Polyembryony is a phenomenon where more than one embryo develops within a single seed. This can occur through several mechanisms, such as the cleavage of the initial zygote or the development of additional embryos from other cells in the ovule, like the synergids or the nucellus. Polyembryony is common in certain plants, such as citrus, and can result in multiple seedlings.

187. (D) The propagule receives water and nutrients from the parent plant until it has rooted.
Layering is a vegetative propagation technique where a stem is induced to form adventitious roots while still attached to the parent plant. The major advantage of this method is that the developing propagule continues to receive water, minerals, and organic nutrients from the parent's vascular system. This significantly reduces environmental stress and increases the success rate of propagation compared to using isolated cuttings.

188. (B) Early embryonic, undifferentiated meristematic cells.
Promeristem, also known as primordial meristem, represents the earliest and most undifferentiated stage of meristematic tissue. It consists of a small group of initial cells and their immediate derivatives located at the very tip of a shoot or root. These cells are embryonic in nature and eventually give rise to the primary meristems, such as protoderm, ground meristem, and procambium during development.

189. (C) Aquatic plants
While most terrestrial plants have root caps to protect the root tip from abrasive soil, many aquatic plants, like Pistia and Lemna, possess root pockets instead. These are loose, thimble-shaped sheaths that cover the root tips. Since water does not provide mechanical resistance, the primary function of root pockets is not protection from abrasion, but they may play a role in sensing.

190. (D) P-3, Q-2, R-1, S-2
In the life cycle of a typical angiosperm, different structures have characteristic ploidy levels. The endosperm is triploid, formed by triple fusion. The nucellus, part of the sporophyte, is diploid. The egg cell is a haploid gamete. The zygote, resulting from the fusion of two haploid gametes, is diploid. These levels reflect the alternation of generations and the unique process of double fertilization.

191. (A) Inside the endodermis, including the pericycle, vascular bundles, and pith.
The stele is the central cylinder of a plant's stem or root. It is defined as all the tissues located interior to the endodermis. This includes the pericycle, which is the outermost layer of the stele, the vascular tissues, and the central pith. The organization and type of the stele can vary significantly between different plant groups, providing important information for botanical classification.

192. (B) Synthesis of plant growth regulators.
The root system primarily functions in anchoring the plant, absorbing water and minerals, and storing food. While roots are known to produce certain hormones like cytokinins, the synthesis of various plant growth regulators is often more associated with other regions of the plant body

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lacks sufficient oxygen for root respiration. To overcome this, these roots grow vertically upward above the water surface and possess small pores called lenticels to facilitate the exchange of gases.

248. (A) Counting the number of annual rings in the trunk.
In temperate regions, the activity of the vascular cambium varies with the seasons, producing distinct layers of secondary xylem each year. The combination of spring wood and autumn wood forms a visible concentric circle known as an annual ring. By counting these rings in a cross-section of a tree trunk, scientists can accurately estimate the chronological age of the tree, a field known as dendrochronology.

249. (C) Axillary bud or stem
A thorn is a hard, pointed, and woody modification of a shoot, typically developing from an axillary bud or a terminal bud. Because they originate from stems, thorns are often associated with nodes and may even bear leaves or flowers. Their primary function is to provide mechanical defense for the plant against browsing animals, effectively deterring them from eating the plant's foliage.

250. (A) Undifferentiated and consists of isodiametric chlorenchyma cells.
In most monocot leaves, the mesophyll tissue located between the upper and lower epidermis is not differentiated into distinct palisade and spongy parenchyma layers. Instead, it consists of a relatively uniform mass of isodiametric chlorenchyma cells with small intercellular spaces. This undifferentiated mesophyll is a characteristic feature of isobilateral leaves, which are commonly found in grasses and other monocotyledonous plant species.

251. (D) Gynoecium with a superior ovary and two fused carpels.
In a floral formula, the letter G represents the gynoecium. A line placed below the G indicates that the ovary is superior. The number 2 in parentheses denotes that the gynoecium is composed of two carpels that are fused together, a condition known as syncarpous. This standardized notation provides a concise way to describe the essential structural characteristics of a flower's female reproductive system.

252. (B) Exine is absent or very thin.
Germ pores are specialized regions on the surface of a pollen grain's outer wall, or exine. In these areas, the highly resistant material sporopollenin is either entirely absent or present in a very thin layer. These pores serve as the exit points for the emerging pollen tube during germination. The number and arrangement of germ pores are important characters used in the taxonomic classification of pollen.

253. (C) Massive, well-developed nucellus.
Ovules are classified as crassinucellate when they possess a relatively large and well-developed mass of nucellar tissue. In these ovules, the megaspore mother cell is located deep within the nucellus, separated from the epidermis by one or more layers of cells. This condition is common in many primitive angiosperms and contrasts with tenuinucellate ovules, where the nucellus is thin or only single-layered.

254. (D) Birds
Ornithophily is the specialized type of pollination carried out by birds, such as hummingbirds and sunbirds. Flowers adapted for bird pollination are often large, tubular, and brightly colored, frequently in shades of red or orange, to attract these visual pollinators. These flowers produce large quantities of dilute nectar as a food reward but typically lack a strong fragrance, as most birds have a limited sense of smell.

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255. (A) Both A and R are true and R is the correct explanation of A.
In angiosperms, the endosperm is a specialized nutritive tissue produced by the process of triple fusion, where a male gamete fuses with two polar nuclei. This results in a triploid tissue that is rich in food reserves like starch and proteins. The primary biological role of the endosperm is to provide the necessary nutrients to the developing embryo, ensuring its successful growth and subsequent germination.

256. (B) Scion
Grafting is a vegetative propagation technique where a scion, the shoot part, is joined to a stock, the root part. While the stock provides the root system and influences the plant's overall vigor and environmental adaptation, the genetic characteristics of the fruit, such as flavor, size, and

202. (A) The fusiform initials are more active towards the inner side.
During secondary growth in dicots, the vascular cambium exhibits differential activity. The fusiform initials typically divide more frequently and produce more cells toward the interior of the stem than toward the exterior. This results in the production of a significantly greater volume of secondary xylem, which forms the wood, compared to the amount of secondary phloem produced on the outer side of the cambium.

203. (D) Petiole is flattened and green, taking the shape and function of a leaf.
A phyllode is a specialized leaf modification where the petiole becomes flattened, widened, and green, resembling a leaf blade. This structure takes over the primary function of photosynthesis, while the true lamina is often reduced or short-lived. This adaptation, commonly seen in certain species of Acacia, helps the plant minimize water loss while maintaining its capacity for producing organic nutrients through photosynthesis.

204. (B) adaxial; abaxial
In the vascular bundles of a leaf, the orientation of tissues is highly specific. The xylem is typically positioned toward the upper or adaxial surface, while the phloem is located toward the lower or abaxial surface. This arrangement is a consequence of the way vascular bundles branch from the stem into the leaf, maintaining the same relative orientation of primary tissues.

205. (C) Aiding in anther dehiscence
The endothecium is a specialized layer of the anther wall located just below the epidermis. Its cells develop fibrous thickenings made of alpha-cellulose. These cells are hygroscopic, meaning they respond to changes in moisture. As the anther matures and dries, the differential contraction of these cells creates mechanical tension, eventually causing the anther to split open and release the mature pollen grains.

206. (D) Funicle
The funicle is the slender, stalk-like structure that attaches an ovule to the placenta within the ovary. It serves as a conduit for water and nutrients delivered from the parent plant to the developing ovule and embryo. The point where the body of the ovule fuses with the funicle is called the hilum, which remains visible as a scar on the mature seed.

207. (A) Anemophily (wind)
Flowers that are small, lack fragrance and nectar, and produce vast quantities of light, dry pollen are specifically adapted for wind pollination, or anemophily. Since wind is a non-directional agency, the production of large amounts of pollen increases the probability of some grains reaching a receptive stigma. These flowers often have exposed anthers and large, feathery stigmas to catch airborne pollen grains.

208. (B) Parthenocarpy
Parthenocarpy is the biological process by which a fruit develops from an ovary without the requirement of fertilization. Consequently, the resulting fruits are typically seedless. This phenomenon can occur naturally or can be induced by the application of certain plant hormones. Parthenocarpic fruits, such as some varieties of bananas, grapes, and citrus, are often preferred for their convenience in human consumption and commercial trade.

209. (B) Pericarp is fused with the seed coat.
A caryopsis is a specialized type of simple, dry, indehiscent fruit characteristic of the grass family, including cereals like wheat, maize, and rice. In a caryopsis, the thin fruit wall, or pericarp, is completely and fused with the underlying seed coat, or testa. This results in a single, grain-like unit where the fruit and seed are essentially inseparable from one another.

210. (A) Nucellus
The nucellus is the central mass of parenchymatous tissue within the ovule, enclosed by one or two integuments. It represents the megasporangium of the plant and provides nutrition for the developing embryo sac. During megasporogenesis, one cell of the nucellus differentiates into the megaspore mother cell. After fertilization, the nucellus is usually consumed, though it may persist as perisperm in some seeds.

211. (C) Shoot apical meristem
The Tunica-Corpus theory is a widely accepted model for describing the cellular organization of the shoot apical meristem. It proposes that

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through the secondary xylem and phloem, facilitating the horizontal or radial transport of water and nutrients. They also serve as important sites for the storage of food reserves like starch.

175. (A) Both A and R are true and R is the correct explanation of A.
Most monocotyledons do not undergo secondary growth because their vascular bundles are closed, meaning they lack a vascular cambium between the xylem and phloem. Without this lateral meristem, the stem cannot produce secondary vascular tissues to increase its girth. This results in the characteristic slender, non-woody stems seen in the vast majority of monocot species, such as grasses and lilies.

176. (B) Heartwood, leading to the blockage of vessels.
Tyloses are balloon-like outgrowths from adjacent parenchyma cells that protrude into the lumen of xylem vessels through pits. Their formation is a characteristic feature of the transition from sapwood to heartwood. These structures effectively block the vessels, preventing the conduction of water and the spread of pathogens. This process increases the durability of the heartwood by sealing off the non-functional vascular tissue.

177. (B) Scattered vascular bundles
Primary anomalous structures are unusual anatomical arrangements that are established during the initial development of a plant's primary body. The most common example is the scattered distribution of vascular bundles throughout the ground tissue, a condition known as atactostele. This is a defining characteristic of monocot stems and represents a fundamental departure from the organized ring of bundles seen in typical dicot stems.

178. (A) Most dicotyledons
Reticulate venation is a characteristic pattern found in the leaves of most dicotyledonous plants. In this arrangement, the veins and veinlets divide repeatedly to form a complex, net-like network throughout the leaf blade. This system provides both a robust framework for structural support and an efficient distribution network for water and nutrients, ensuring that every part of the leaf is well-supplied.

179. (C) C4 photosynthesis, often in high temperature and light conditions.
Kranz anatomy is a specialized leaf structure found in C4 plants, such as maize and sugarcane. It is characterized by a ring of large bundle sheath cells surrounding the vascular bundles, which are in turn surrounded by mesophyll cells. This organization physically separates the different stages of photosynthesis, allowing the plant to minimize photorespiration and efficiently fix carbon dioxide, especially in hot, bright environments.

180. (D) II, III, IV, I
The development of a dicot embryo progresses through several distinct morphological stages. It begins with the zygote, which divides to form a globular proembryo. As the cotyledons begin to develop, the embryo assumes a heart-shaped appearance. This is followed by the torpedo stage, where the cotyledons elongate. Finally, the embryo matures, becoming ready for dormancy and eventual germination into a seedling.

181. (C) Petal, Petal, Stamen, Stamen
According to the ABC model of floral development, the loss of A-function genes typically allows C-function genes to expand their expression into the outer whorls. In this specific scenario, the absence of A-function, combined with the presence of other genes, leads to a transformation where the outer whorls develop as petals and the inner whorls develop as stamens, following the provided result.

182. (B) Two lobes and four microsporangia.
A dithecous anther is the most common type found in flowering plants. It consists of two distinct anther lobes, which are typically joined by a connective tissue. Each lobe contains two pollen sacs, or microsporangia, resulting in a total of four microsporangia per anther. This organization allows for the efficient production and eventual release of a large number of pollen grains.

183. (B) haploid; triploid
In gymnosperms, the endosperm is a pre-fertilization tissue that represents the female gametophyte, and it is haploid. In contrast, the endosperm in most angiosperms is a post-fertilization tissue formed by the fusion of a male

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into a healthy seedling. A viable seed is one that is physiologically capable of resuming active growth once it is provided with the necessary environmental conditions, such as water, oxygen, and an appropriate temperature. The duration of viability varies significantly among different plant species and storage conditions.

221. (C) Modified fleshy leaf bud
A bulbil is a specialized vegetative propagule that is essentially a modified, fleshy axillary or floral bud. These buds become swollen with stored food reserves and eventually detach from the parent plant. When they fall onto suitable soil, they can germinate and develop into new, independent plants. Common examples of plants that utilize bulbils for asexual reproduction include Agave and certain species of lilies.

222. (D) Resist damage and act as a reservoir for restoring the meristem.
The quiescent center is a group of slowly dividing cells located at the heart of the root apical meristem. Because these cells divide infrequently, they are less susceptible to genetic mutations and mechanical damage. Their primary function is to serve as a stable reservoir of initials that can be activated to divide and regenerate the active meristematic tissues if they become injured or exhausted.

223. (A) Furrowed xylem as in Bignonia.
A unique form of anomalous secondary growth is seen in the stem of Bignonia, where the vascular cambium exhibits unequal activity in different regions. In four specific areas, the cambium produces more secondary phloem than secondary xylem, leading to the formation of deep wedges or furrows of phloem embedded within the wood. This results in the characteristic furrowed xylem appearance seen in transverse sections.

224. (B) Stomata concentrated on the lower epidermis to facilitate gas exchange while minimizing water loss.
Dicot leaves are adapted for efficient photosynthesis while managing water loss. Most stomata are located on the lower epidermis, protected from direct sunlight and wind, which reduces transpiration rates. This distribution allows for necessary carbon dioxide uptake for photosynthesis during the day. The internal arrangement of palisade and spongy parenchyma further optimizes light absorption and gas diffusion within the leaf's tissues for maximum productivity.

225. (B) I, II, III, IV
The development of a typical female gametophyte follows a precise sequence. It begins with meiosis of the megaspore mother cell to produce four haploid megaspores. Three of these typically degenerate, leaving one functional megaspore. The nucleus of this functional megaspore then undergoes three successive mitotic divisions, resulting in eight nuclei. Finally, these nuclei are organized into a seven-celled, eight-nucleate mature embryo sac.

226. (A) A stamen is fertile, and a staminode is sterile.
In floral morphology, a stamen is the functional male reproductive organ that produces viable pollen grains within its anthers. In contrast, a staminode is a sterile or rudimentary stamen that does not produce pollen. Staminodes may be reduced in size or modified into petal-like structures, often serving other roles such as attracting pollinators, though they no longer participate directly in sexual reproduction.

227. (C) Nucellus is single-layered or poorly developed.
Ovules are categorized based on the amount of nucellar tissue they possess. A tenuinucellate ovule is one in which the nucellus is very thin and poorly developed, often consisting of only a single layer of cells around the developing embryo sac. This condition is typically found in plants with gamopetalous corollas. It contrasts with crassinucellate ovules, which have a much more massive and well-developed nucellus.

228. (D) The spatial separation of the anthers and stigma within a flower.
Herkogamy is a physical mechanism that promotes cross-pollination by creating a spatial separation between the male and female reproductive organs within the same flower. For example, the stigma may be positioned much higher than the anthers, or there may be mechanical barriers between them. This distance prevents the flower's own pollen from reaching its stigma, thereby reducing the likelihood of self-fertilization.

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the meristem is divided into an outer tunica, consisting of layers that divide anticlinally to increase surface area, and an inner corpus, a mass of cells that divide in various planes to increase the volume of the shoot during primary growth.

212. (D) Tinospora and Trapa
Assimilatory roots, also known as photosynthetic roots, are specialized adventitious roots that contain chlorophyll and can perform photosynthesis. These roots are typically green in color. In plants like Tinospora and Trapa, these roots become highly developed and contribute significantly to the plant's overall energy budget. This adaptation is particularly useful for plants growing in environments where leaf surface area might be limited or submerged.

213. (C) Interfascicular cambium develops from medullary rays and joins the intrafascicular cambium.
In a dicot stem, a continuous vascular cambium ring is formed by the union of two types of meristematic tissue. The intrafascicular cambium is already present within the vascular bundles. During the onset of secondary growth, certain cells of the medullary rays located between the bundles become meristematic, forming the interfascicular cambium. These two segments join to form a complete, active ring of lateral meristem.

214. (B) All tissues exterior to the vascular cambium.
In non-technical terms, bark is considered to be all the tissue layers found on the outside of the vascular cambium in a woody stem or root. This includes the functional and non-functional secondary phloem, the remaining cortex, and the entire periderm. The bark provides essential protection against mechanical injury, water loss, and entry of pathogens, while the phloem within it transports organic nutrients.

215. (A) Both A and R are true and R is the correct explanation of A.
In the ABC model of floral development, A and C class genes are mutually antagonistic. Normally, A-class genes function in the outer whorls and C-class genes in the inner whorls. If a C-class gene is mutated and non-functional, the A-class gene's expression expands into all four whorls. This leads to the transformation of reproductive organs into perianth organs, specifically resulting in sepals and petals.

216. (A) Androgenesis
Androgenesis is a biological process where an embryo develops from a male gamete, such as a pollen grain or a sperm cell, without the contribution of a female gamete's nucleus. This can occur naturally or be induced in a laboratory setting through tissue culture. The resulting individual is typically haploid, containing only the genetic material from the male parent, which is valuable for certain breeding programs.

217. (C) It results in the formation of a diploid zygote and a diploid endosperm.
Double fertilization is a characteristic process in angiosperms involving two fusion events. One male gamete fuses with the egg cell to form a diploid zygote. The second male gamete fuses with two polar nuclei to form the triploid primary endosperm nucleus. The statement that it results in a diploid endosperm is incorrect, as the fusion of three haploid nuclei naturally produces a triploid tissue.

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218. (A) Apogamy
Apogamy is a type of apomixis where an embryo develops from a cell of the female gametophyte other than the egg cell, such as a synergid or an antipodal cell, without the process of fertilization. Since these cells are part of the haploid gametophyte, the resulting embryo is typically haploid. This process represents a deviation from the normal sexual cycle where only the egg cell forms the embryo.

219. (D) Spike or spadix inflorescence
A sorosis is a type of multiple or composite fruit that develops from a complete inflorescence, specifically a spike, spadix, or catkin. In this fruit type, the flowers, their peduncles, and the central fleshy axis all fuse together as they mature. Common examples of sorosis include pineapple, mulberry, and jackfruit, where the individual fruits of many flowers combine to form a single, large reproductive structure.

220. (B) Germinate under suitable environmental conditions.
Seed viability refers to the ability of a seed to remain alive and retain its capacity to germinate

B, and C class genes determines the identity of sepals, petals, stamens, and carpels. If all three gene classes are mutated and non-functional, the floral meristem defaults to a vegetative-like developmental state. As a result, the four whorls of the flower will produce structures that closely resemble small, green vegetative leaves.

239. (A) Amoeboid tapetum involves the breakdown of inner walls and protoplast fusion.
The tapetum is the innermost nutritive layer of the anther wall. In the amoeboid or plasmodial type, the inner and radial walls of the tapetal cells break down, and their protoplasts fuse to form a multinucleate mass that moves into the locule to surround the developing microspores. In the secretory or glandular type, the cells remain intact and secrete nutrients into the locule throughout development.

240. (B) Style
The style is the slender, tube-like portion of the pistil that connects the stigma to the ovary. After a pollen grain germinates on the stigma, the resulting pollen tube grows down through the tissues of the style. The style provides both mechanical support and guidance for the pollen tube, ensuring that the male gametes are delivered directly to the ovules located within the ovary.

241. (B) To fuse with a male gamete to form the primary endosperm nucleus.
The polar nuclei are two haploid nuclei located in the large central cell of the embryo sac. During the process of double fertilization, the second male gamete fuses with both polar nuclei in a process called triple fusion. This results in the formation of a triploid primary endosperm nucleus, which then undergoes multiple divisions to develop into the nutritive endosperm tissue for the embryo.

242. (A) Diploid (2n)
While most angiosperms have a triploid endosperm resulting from triple fusion, Oenothera exhibits a unique variation. In this genus, the embryo sac is monosporic and only four-nucleate, containing only one polar nucleus instead of two. Consequently, when the male gamete fuses with this single polar nucleus, the resulting primary endosperm nucleus is diploid rather than triploid, representing a significant departure from the typical angiosperm pattern.

243. (C) Primary root
In the embryo of a dicot plant, the radicle is the embryonic root located at the basal end of the embryonal axis. Upon germination, the radicle is the first part to emerge from the seed coat. It grows downward into the soil to become the primary root, which subsequently gives rise to lateral roots, forming the foundation of the plant's entire root system.

244. (D) Monocarpellary ovary and dehisces along both sutures.
A legume, or pod, is a simple dry fruit characteristic of the Fabaceae family. It develops from a monocarpellary, superior ovary with a single chamber. When mature, the dry pericarp of the legume splits open, or dehisces, along both the dorsal and ventral sutures to release its seeds. This dual-suture opening mechanism is a defining feature of the legume fruit type.

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245. (D) I, II, and III
Seed dispersal is essential for plant survival and uses various agencies. Zoochory refers to dispersal by animals, which may carry seeds on their fur or eat fruits and deposit seeds elsewhere. Anemochory is dispersal by wind, facilitated by lightweight or winged seeds. Hydrochory is dispersal by water, common in aquatic and coastal plants. All three terms correctly describe these fundamental ecological dispersal mechanisms.

246. (B) Periblem
According to the histogen theory of root apical meristems, the meristem is organized into layers that give rise to specific tissues. The periblem is the middle histogen layer located between the dermatogen and the plerome. As its cells divide and differentiate, the periblem gives rise to the primary ground tissue of the root, which primarily forms the extensive cortex located between the epidermis and the stele.

247. (D) Marshy, saline swamps
Pneumatophores, also known as respiratory or knee roots, are specialized root modifications found in mangrove plants like Rhizophora that grow in marshy, saline swamps. In these environments, the soil is waterlogged and

229. (C) Multiple fruit
A multiple fruit, also known as a composite fruit, is one that develops from an entire inflorescence rather than a single flower. In this case, the individual ovaries of many closely clustered flowers, along with other associated floral parts like the axis and bracts, fuse together as they mature. Familiar examples of multiple fruits include pineapples, figs, and mulberries, which represent a complex reproductive structure.

230. (A) P-3, Q-1, R-4, S-2
Fruits are classified into different types based on their structural characteristics. A drupe, like a mango, has a stony endocarp. A berry, such as a tomato, is entirely fleshy with many seeds. A pome, like a pear, is a false fruit where the thalamus is edible. A hesperidium, characteristic of citrus fruits like oranges, is a specialized berry with a leathery rind and juice-filled hairs.

231. (D) Stem
Layering is an artificial method of vegetative propagation where a stem is induced to develop adventitious roots while still physically attached to the parent plant. This is typically achieved by bending a branch to the ground and covering a portion of it with moist soil. Because the stem remains connected to the parent, it continues to receive water and nutrients, ensuring a high success rate.

232. (A) At the center of the stele.
In a dicot root, the primary xylem is formed during early development and is arranged in a radial pattern with the protoxylem toward the periphery and metaxylem toward the center. As secondary growth occurs, the vascular cambium produces secondary xylem toward the inside. This pushes the primary xylem further toward the very center of the root, where it remains as a permanent central core.

233. (C) fixed nitrogen; carbohydrates
The symbiotic relationship between legumes and Rhizobium bacteria is based on a mutual exchange of essential resources. The bacteria, living within specialized root nodules, convert atmospheric nitrogen into a fixed form, like ammonia, which the plant can use for growth. In return, the plant provides the bacteria with organic nutrients, primarily carbohydrates produced during photosynthesis, which serve as an energy source for the bacteria.

234. (A) Monocot stem
Monocot stems are anatomically characterized by having numerous vascular bundles scattered throughout the ground tissue, an arrangement known as an atactostele. These bundles are conjoint, collateral, and closed, meaning they lack a cambium for secondary growth. Each bundle is often enclosed by a protective sclerenchymatous sheath. This scattered distribution differs fundamentally from the organized ring-like arrangement of vascular bundles typically found in dicotyledonous stems.

235. (D) Inner side
Phellogen, or cork cambium, is a lateral meristem that produces the protective periderm during secondary growth. It exhibits bipolar activity, dividing to produce two different types of tissues. On its outer side, it produces phellem, or cork cells, which are heavily suberized. On its inner side, it produces phelloderm, or secondary cortex, which consists of parenchymatous cells that remain living and functional within the plant.

236. (B) Cortical vascular bundles
Nyctanthes exhibits a primary anatomical anomaly where vascular bundles are found within the cortex, outside the main vascular cylinder. These cortical bundles are typically small and are oriented with their xylem facing toward the exterior of the stem. This unusual arrangement is established during the initial growth of the shoot and is a characteristic feature used to identify the anatomy of this specific plant genus.

237. (C) The division of the lamina into multiple leaflets.
A compound leaf is distinguished from a simple leaf by the structure of its lamina, or leaf blade. In a simple leaf, the lamina is undivided, though it may be lobed. In a compound leaf, the lamina is completely divided into two or more distinct segments called leaflets. While both have an axillary bud at the base of the petiole, leaflets never possess their own axillary buds.

238. (D) Structures resembling leaves in all whorls
According to the ABC model of floral development, the specific combination of A,

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color, are entirely determined by the genotype of the scion. This allows for the consistent production of high-quality fruit varieties.

257. (B) Dahlia
Fasciculated tuberous roots are a type of root modification for food storage where several fleshy roots develop in a cluster at the base of the stem. Unlike a single taproot tuber, these are adventurous roots that arise together. Dahlia is a well-known example of a plant that utilizes this specific storage strategy. These swollen roots store starch and other nutrients, enabling the plant to survive dormancy and regrow.

258. (A) Its conducting elements (sieve tubes) are delicate and lack nuclei at maturity, eventually being crushed.
Secondary phloem is the tissue responsible for transporting organic nutrients produced during photosynthesis. Unlike the woody secondary xylem, the cells of the secondary phloem, especially the sieve tube elements, are thin-walled and lack nuclei at maturity. As the stem increases in girth through the production of massive amounts of secondary xylem, the older, delicate phloem tissues are eventually crushed and replaced by new functional layers.

259. (C) Stems
Tendrils are slender, sensitive, thread-like structures that help weak-stemmed plants climb by coiling around support. In many plants, such as grapevines and pumpkins, these tendrils develop from the axillary buds, which are embryonic shoots. Because they originate from the same position as a branch and share its basic anatomical structure, these tendrils are considered to be specialized stem modifications rather than modified leaves or other structures.

260. (D) Isobilateral and monocotyledonous
Isobilateral leaves are characteristic of many monocots, such as grasses. They are typically oriented vertically, meaning both surfaces receive similar amounts of sunlight. Anatomically, this leads to approximately equal distributions of stomata on both the upper and lower epidermis. Furthermore, the internal mesophyll tissue is usually not differentiated into distinct palisade and spongy layers, reflecting the uniform environmental conditions experienced by both sides of the leaf.

261. (C) A and B together
The ABC model of floral organ development specifies the identity of petals through the simultaneous expression of A-class and B-class homeotic genes. These genes act within the second whorl of the floral meristem. When both classes are active, they trigger a developmental pathway that transforms meristematic cells into petals. If either class is missing due to mutation, the second whorl will develop into a different organ type.

262. (B) Microsporogenesis
Microsporogenesis is the process of formation of microspores within the microsporangium, or pollen sac, of an anther. It involves the meiotic division of diploid microspore mother cells to produce haploid microspores, which are initially arranged in tetrads. This process is the first stage in the development of the male gametophyte and is essential for producing the pollen grains required for the sexual reproduction of flowering plants.

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263. (D) Being straight, with the micropyle, chalaza, and funicle in a single line.
An orthotropous ovule is the simplest and most primitive type of ovule. It is characterized by being completely straight and upright. In this orientation, the micropyle, the chalaza, and the funicle are all aligned in a single straight vertical line. This type of ovule is less common than the inverted anatropous type but can still be found in certain plant families such as the Polygonaceae and Piperaceae.

264. (A) Haploid (n)
Antipodal cells are a group of three cells found at the chalazal end of the mature embryo sac in a typical Polygonum-type development. Since the embryo sac itself develops from a single haploid megaspore through mitotic divisions, all of its constituent cells, including the antipodals, the synergids, and the egg cell, are haploid. These cells contain only one set of chromosomes, representing the gametophytic generation.

265. (C) Vallisneria
Vallisneria is a classic example of a plant that exhibits hydrophily, or pollination by water. In this submerged aquatic plant, the female flowers reach the water surface on long stalks, while the male flowers detach and float on the surface. When a male flower comes into contact with a female flower through water currents, pollen is transferred. This specialized mechanism ensures successful reproduction within a fully aquatic environment.

266. (A) Emasculation
Emasculation is a critical technique used in artificial hybridization to prevent self-pollination in bisexual flowers. It involves the careful removal of the anthers from the flower bud before they have a chance to release pollen. This process ensures that the stigma of the flower can only be fertilized by pollen specifically chosen and applied by the plant breeder, allowing for the creation of desired hybrid varieties.

267. (D) Follows every nuclear division of the primary endosperm nucleus.
In the cellular type of endosperm development, the process of cytokinesis, or cell wall formation, is closely coupled with nuclear division. Each time the primary endosperm nucleus or its derivatives divide by mitosis, a new cell wall is immediately formed between the resulting nuclei. This results in the endosperm being a fully cellular tissue from the very beginning of its development, without a free-nuclear phase.

268. (B) Contributes significantly to the embryo proper.
In the Asterad type of embryogeny, which is common in many dicotyledonous families, the zygote undergoes a transverse division to form an apical cell and a basal cell. A distinguishing feature of this type is that both the apical cell and the basal cell participate significantly in the formation of the embryo proper. This contrasts with other types where the basal cell primarily forms the suspensor structure.

269. (C) Endosperm
The edible part of a mature coconut is the endosperm, which provides nutrition for the developing embryo. It exists in two forms: the clear liquid coconut water is the free-nuclear endosperm, and the firm white kernel is the cellular endosperm. Together, they represent a massive accumulation of food reserves, including fats and proteins, that are characteristic of this large, specialized drupe-like fruit and its unique seed.

270. (D) Albuminous
Albuminous seeds, also known as endospermic seeds, are those in which the endosperm tissue persists and remains the primary site for food storage even when the seed is fully mature. In these seeds, such as castor, maize, and coconut, the embryo does not completely consume the endosperm during its development. This stored energy is then used to support the young seedling during the initial stages of its germination.

271. (A) Pistia and Eichhornia
An offset is a specialized type of sub-aerial stem modification used for vegetative propagation in certain aquatic plants. It is a short, thick, horizontal branch that originates from a leaf axil and grows along the water surface. At its tip, it produces a rosette of leaves and a tuft of adventitious roots. Common examples include water lettuce and water hyacinth, which can rapidly cover water bodies.

272. (B) Pericycle
The pericycle is the outermost layer of the stele, located immediately interior to the endodermis. It typically consists of one or more layers of parenchymatous or sometimes sclerenchymatous cells. In roots, the pericycle is a highly significant tissue because it is the site of origin for lateral roots and contributes to the formation of the vascular and cork cambiums during the process of secondary growth.

273. (B) Epidermis
Velamen is a specialized, multi-layered epidermal tissue found on the aerial roots of many epiphytic plants, such as orchids. It consists of dead cells with reinforced walls that function like a sponge, allowing the roots to rapidly absorb and store moisture and dissolved nutrients directly from the atmosphere. This adaptation is essential for survival in habitats where the plant lacks access to soil and stable water sources.

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274. (A) Amphivasal
An amphivasal vascular bundle is a type of concentric bundle where the xylem completely surrounds the central core of phloem. This arrangement is the opposite of an amphicribral bundle, where phloem surrounds xylem. Amphivasal bundles are relatively uncommon but can be found in the stems of certain monocotyledons, such as Dracaena, and in some specialized reproductive structures, providing a unique anatomical variation in plant tissue organization.

275. (B) P-4, Q-3, R-1, S-2
Different plants exhibit unique anatomical anomalies. Dracaena shows anomalous secondary growth despite being a monocot. Boerhaavia is known for having successive rings of vascular cambium. Bignonia exhibits furrowed xylem with phloem wedges. Strychnos is characterized by the presence of medullary vascular bundles within its pith. These variations provide important diagnostic features for identifying specific plant genera and families based on their internal stem anatomy.

276. (D) Guttation
Guttation is the process where plants lose water in liquid form through specialized structures called hydathodes, located at the tips or margins of leaves. This phenomenon typically occurs at night or in the early morning when soil moisture is high and transpiration is low. Root pressure pushes the water up and out of the plant. It is commonly observed in various grasses, tomatoes, and other small herbaceous plants.

277. (C) Stamens are fused by their anthers, but filaments are free.
The term syngenesious describes a specific type of cohesion within the androecium of a flower. In this condition, the stamens are fused together by their anthers to form a tube around the style, while their filaments remain entirely free and separate from one another. This arrangement is a characteristic feature of the Asteraceae family, including sunflowers, and plays a role in the specialized pollination mechanisms of these plants.

278. (B) Small, spindle-shaped, and floats in the cytoplasm of the vegetative cell.
The generative cell is one of the two cells formed within a developing pollen grain. It is typically much smaller than the vegetative cell and has a characteristic spindle-shaped appearance. The generative cell floats within the cytoplasm of the larger vegetative cell. Its primary biological function is to undergo a final mitotic division to produce the two male gametes required for double fertilization in the embryo sac.

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279. (D) Bisporic
The Allium type of embryo sac development is classified as bisporic. This means that after the first meiotic division of the megaspore mother cell, cytokinesis occurs, but it does not follow the second meiotic division. This results in two dyad cells, each containing two haploid nuclei. One of these dyad cells eventually develops into the mature eight-nucleate female gametophyte, as seen in the common onion and related species.

280. (A) It ensures that the nutritive tissue (endosperm) is formed only if fertilization of the egg occurs.
Double fertilization is an efficient reproductive strategy in angiosperms because the production of the energy-rich endosperm tissue is strictly linked to the successful fertilization of the egg cell. This ensures that the plant does not waste metabolic resources developing a nutritive tissue if no embryo is present to utilize it. This coordination between embryo and endosperm development is a key factor in the evolutionary success of flowering plants.

281. (C) Epicarp, mesocarp, and endocarp
The pericarp is the fruit wall that develops from the ovary wall after fertilization. In many fleshy fruits, it is clearly differentiated into three distinct layers. The epicarp is the outermost skin. The mesocarp is the middle layer, which is often thick and fleshy or fibrous. The endocarp is the innermost layer, which may be thin, fleshy, or hard and stony, as seen in various drupes.

282. (A) Apomixis (sporophytic budding)
Adventive embryony is a form of apomixis where one or more embryos develop directly from diploid sporophytic cells of the ovule, such as those in the nucellus or integuments, bypassing the process of fertilization. This process, also

31. Match List I with List II regarding cellular respiration.
List I: (Process)
P. Glycolysis
Q. Citric Acid Cycle
R. Oxidative Phosphorylation
S. Photorespiration
List II: (Location/Product)
1. Mitochondrial inner membrane
2. Cytosol
3. Release of CO_2 in a wasteful process
4. Mitochondrial matrix
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-2, R-1, S-3

32. All of the following are products of the citric acid cycle EXCEPT:
(A) ATP (or GTP)
(B) Pyruvate
(C) NADH
(D) FADH2

33. Which enzyme is responsible for the assimilation of ammonium into amino acids via the GS-GOGAT pathway?
(A) Nitrate reductase
(B) Glutamine synthetase
(C) Nitrite reductase
(D) Nitrogenase

34. The biosynthesis of which plant hormone is primarily derived from the amino acid tryptophan?
(A) Indole-3-acetic acid (Auxin)
(B) Gibberellic acid (Gibberellin)
(C) Zeatin (Cytokinin hormone)
(D) Ethylene (Gaseous hormone)

35. The process of senescence in plants is characterized by all of the following EXCEPT:
(A) A decline in photosynthetic activity.
(B) The breakdown of chlorophyll, proteins, and nucleic acids.
(C) An increase in cell division and growth.
(D) The mobilization of nutrients from aging leaves to other parts of the plant.

36. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Nitrate must be reduced to ammonium before it can be assimilated into organic compounds.
Reason (R): Plant enzymes can directly incorporate nitrate into amino acids.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

37. A farmer notices that their fruit is ripening too quickly in storage. The accumulation of which gaseous plant hormone is the most likely cause?
(A) Auxin
(B) Gibberellin
(C) Ethylene
(D) Abscisic acid

38. The "triple response" in seedlings (inhibition of stem elongation, promotion of lateral swelling, and enhanced apical hook curvature) is a classic physiological effect of:
(A) Cytokinins
(B) Ethylene
(C) Gibberellins
(D) Brassinosteroids

39. Given below are two statements:
Statement I: Auxins promote apical dominance, where the central stem grows more strongly than the lateral stems.
Statement II: Cytokinins promote lateral bud growth and antagonize apical dominance.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

40. Which of the following is a primary physiological effect of gibberellins?
(A) Promoting stem elongation and seed germination
(B) Promoting stomatal closure
(C) Inducing seed dormancy
(D) Inhibiting cell division

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a seed that contains a well-developed perisperm. This tissue provides additional food reserves for the embryo during germination, supplementing or sometimes replacing the endosperm as the primary source of nutrition for the young developing plant.

292. (D) Prevent contamination from unwanted pollen.
In the process of artificial hybridization, bagging involves covering the emasculated flowers with a protective bag, typically made of butter paper. This step is essential to prevent the receptive stigma from being contaminated by foreign or unwanted pollen carried by wind or insects. By ensuring that only the chosen pollen is applied, plant breeders can precisely control the genetic crosses and produce specific hybrid varieties.

293. (C) False, as it originates partly from the conjunctive tissue and partly from the pericycle.
In a dicot root, the vascular cambium is completely secondary in origin, meaning it forms entirely after the primary plant body has developed. It is not a primary meristem. It originates from the dedifferentiation of the conjunctive tissue located just below the phloem bundles and from the portions of the pericycle tissue located outside the protoxylem. These segments eventually unite to form a continuous, active meristematic ring.

294. (B) Tracheary elements are filled with tyloses and depositions of organic compounds.
Heartwood is the older, central portion of a woody stem that no longer functions in water conduction. Its tracheary elements, such as vessels and tracheids, become blocked by balloon-like outgrowths called tyloses and the deposition of various organic substances like tannins, resins, and oils. These changes make the heartwood dark, hard, and extremely durable, providing significant mechanical support while effectively resisting decay and microbial attacks.

295. (D) Opposite decussate
Calotropis exhibits a specific pattern of leaf arrangement known as opposite decussate. In this type of phyllotaxy, two leaves arise at each node on opposite sides of the stem. Each successive pair of leaves is oriented at a right angle to the pair immediately above and below it. This three-dimensional arrangement ensures that the leaves are efficiently spaced to capture maximum sunlight while minimizing the shading of lower leaf layers.

296. (A) Pollination
Pollination is the fundamental process in the sexual reproduction of flowering plants involving the physical transfer of pollen grains from the anther, where they are produced, to the receptive stigma of a pistil. This transfer can be achieved through self-pollination or cross-pollination and is often facilitated by various external agencies, such as wind, water, or animals, ensuring the delivery of male gametes.

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297. (C) Monosporic and 8-nucleate
The Polygonum type is the most common form of embryo sac development in angiosperms. It is classified as monosporic because it develops from a single functional megaspore. Through three successive mitotic nuclear divisions, it produces an eight-nucleate structure. These nuclei then organize into seven cells: three antipodals, two synergids, one egg cell, and one large central cell containing two polar nuclei, representing a mature female gametophyte.

298. (A) Hypocotyl
In a dicot embryo, the hypocotyl is the portion of the embryonal axis located below the point of attachment of the cotyledons. It terminates at its lower end in the radicle, the embryonic root. During the process of germination, the elongation of the hypocotyl can push the cotyledons above the soil surface, as seen in epigeal germination, playing a critical role in early seedling establishment.

299. (D) Asteraceae
A cypsela is a specialized type of simple, dry, indehiscent fruit that is characteristic of the Asteraceae family. It develops from a bicarpellary, syncarpous, and inferior ovary. A unique feature of the cypsela is that it is often crowned by a pappus, which is a modified calyx consisting of hairs or bristles that aids in the wind dispersal of the single internal seed.

300. (B) Stem cuttings (setts)
Sugarcane is almost exclusively propagated through vegetative means rather than using seeds. This involves planting stem cuttings,

(C) A is true but R is false.
(D) A is false but R is true.

9. The pressure-flow hypothesis is the most widely accepted mechanism for:
(A) The ascent of sap in xylem.
(B) The opening and closing of stomata.
(C) The translocation of photoassimilates in phloem.
(D) The absorption of water by roots.

10. A plant cell placed in a hypertonic solution will likely experience:
(A) Plasmolysis
(B) Turgor
(C) Cytolysis
(D) Guttation

11. Consider the following statements about mineral nutrition.
I. Macronutrients are required in large quantities, typically >10 mmole/kg of dry matter.
II. Micronutrients, or trace elements, are needed in very small quantities.
III. Boron and Zinc are considered macronutrients.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I only
(D) All I, II, and III

12. Which of the following is NOT a primary function of the light-harvesting complex in photosynthesis?
(A) Absorbing light energy
(B) Fixing carbon dioxide
(C) Transferring excitation energy to the reaction center
(D) Protecting the photosynthetic apparatus from excess light

13. The primary function of the C4 pathway is to:
(A) Fix CO_2 at night to conserve plant water.
(B) Directly produce glucose in mesophyll cells.
(C) Concentrate CO_2 to reduce photorespiration.
(D) Generate ATP and NADPH in the dark.

14. During the light-dependent reactions of photosynthesis, the mechanism of electron transport results in the pumping of protons from the:
(A) Thylakoid lumen to the stroma.
(B) Cytosol to the stroma.
(C) Stroma to the intermembrane space of the chloroplast.
(D) Stroma to the thylakoid lumen.

15. Given below are two statements:
Statement I: CAM plants fix CO_2 during the night and perform the Calvin cycle during the day.
Statement II: This temporal separation of processes helps CAM plants to minimize water loss in arid environments.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

16. The final electron acceptor in the non-cyclic electron transport chain of photosynthesis is:
(A) Oxygen
(B) NADP+
(C) Water
(D) ATP

17. Which of the following is a key enzyme in the C3 pathway of CO_2 fixation?
(A) Phosphoenolpyruvate carboxylase
(B) Ribulose-1,5-bisphosphate carboxylase
(C) Malate dehydrogenase enzyme
(D) Cytosolic pyruvate kinase

18. Arrange the following events of non-cyclic photophosphorylation in the correct chronological order:
I. Excitation of P680
II. Reduction of NADP+
III. Photolysis of water
IV. Excitation of P700
(A) III, I, IV, II
(B) I, III, II, IV
(C) I, IV, III, II
(D) III, IV, I, II

19. Xanthophyll cycle is an example of a:
(A) Photo-oxidative damage mechanism.
(B) CO_2 fixation pathway.
(C) Photo-protective mechanism.
(D) Water splitting process.

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CHAPTER 05
Plant Physiology and Biochemistry

1. Which of the following terms best describes the combined movement of water from the soil, through the plant, and into the atmosphere?
(A) Translocation
(B) Transpiration
(C) Guttation
(D) Imbibition

2. Given below are two statements regarding plant water relations:
Statement I: Water potential is the measure of the potential energy of water, which drives the movement of water.
Statement II: Water always moves from a region of lower water potential to a region of higher water potential.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

3. Which component of water potential becomes most significant in a plasmolysed plant cell?
(A) Pressure potential
(B) Gravitational potential
(C) Solute potential
(D) Matrix potential

4. The uptake of mineral ions from the soil into the root cells primarily occurs through which process?
(A) Passive diffusion only
(B) Bulk flow
(C) Imbibition
(D) Active transport

5. Which of the following statements about phloem loading is incorrect?
(A) It is an active process that requires metabolic energy.
(B) It involves moving photoassimilates from mesophyll cells to sieve-tube elements.
(C) Water moves out of the phloem into the xylem after loading.
(D) Phloem loading decreases the solute potential in the sieve-tube elements.

6. Match List I with List II regarding transport mechanisms in plants.
List I: (Mechanism)
P. Apoplast pathway
Q. Symplast pathway
R. Transmembrane pathway
S. Xylem transport
List II: (Description)
1. Movement of water through plasmodesmata
2. Bulk flow of water and minerals
3. Movement of water across cell membranes
4. Movement of water through intercellular spaces and cell walls
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

7. The opening of stomata is primarily caused by:
(A) A decrease in the turgor pressure of the guard cells.
(B) An increase in abscisic acid (ABA) concentration.
(C) A decrease in the solute concentration within the guard cells.
(D) An increase in the turgor pressure of the guard cells.

8. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The transport of water through the xylem is a passive process.
Reason (R): The cohesion-tension theory explains that transpiration pull is the main driving force for water ascent.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.

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known as setts, which contain several nodes with healthy axillary buds. This method ensures that the new crop is genetically identical to the parent, maintaining specific desirable traits like high sugar content and disease resistance. Vegetative propagation also allows for a faster and more reliable establishment of the crop.

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20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): C4 plants are photosynthetically more efficient than C3 plants in hot, dry climates.
Reason (R): C4 plants possess a mechanism to concentrate CO_2 at the site of RuBisCO, thereby minimizing photorespiration.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

21. In CAM plants, malic acid is stored during the night in the:
(A) Chloroplasts
(B) Mitochondria
(C) Vacuoles
(D) Cytosol

22. Which of the following is an incorrect pair of pathway and its primary CO_2-fixing enzyme?
(A) C3 pathway - RuBisCO enzyme
(B) C4 pathway - RuBisCO in mesophyll
(C) C4 pathway - PEP Carboxylase
(D) CAM pathway - PEP Carboxylase at night

23. The process of glycolysis occurs in which part of a plant cell?
(A) Mitochondrion
(B) Chloroplast stroma
(C) Peroxisome
(D) Cytosol

24. Consider the following statements about the citric acid cycle.
I. It takes place in the mitochondrial matrix.
II. It begins with the reaction of acetyl-CoA and oxaloacetate.
III. It is an anaerobic process.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) III only
(D) All I, II, and III

25. The plant mitochondrial electron transport system differs from the animal system by possessing:
(A) Cytochrome c electron carriers.
(B) Membrane-bound ATP synthase.
(C) Alternative oxidase pathways.
(D) Complex I NADH dehydrogenase.

26. Photorespiration involves the interaction of which three organelles?
(A) Chloroplast, Peroxisome, and Mitochondrion
(B) Chloroplast, Mitochondrion, and Nucleus
(C) Mitochondrion, Golgi apparatus, and Peroxisome
(D) Chloroplast, Endoplasmic reticulum, and Vacuole

27. What is the net gain of ATP molecules from one molecule of glucose during glycolysis?
(A) 4 ATP
(B) 36 ATP
(C) 8 ATP
(D) 2 ATP

28. The oxygenase activity of RuBisCO initiates which of the following metabolic pathways?
(A) Glycolysis
(B) Photorespiration
(C) Citric acid cycle
(D) C4 pathway

29. Given below are two statements:
Statement I: The final electron acceptor in the plant mitochondrial electron transport chain is oxygen.
Statement II: ATP synthesis in mitochondria is coupled to the proton gradient generated by the electron transport chain.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

30. The function of the alternative oxidase (AOX) pathway in plant mitochondria is best described as:
(A) Maximizing the yield of ATP.
(B) Pumping protons into the lumen.
(C) Reducing NAD+ to NADH directly.
(D) Preventing system over-reduction.

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known as sporophytic budding, often leads to polyembryony. Because these embryos are derived from maternal tissue without genetic recombination, they are genetically identical to the parent plant, effectively producing clones.

283. (D) Jasmine and Bougainvillea
Layering is an artificial vegetative propagation method widely used in the horticultural industry for plants that do not easily grow from cuttings. In this process, a living branch is bent to the ground and covered with soil to induce root formation while still receiving nutrients from the parent. Jasmine and Bougainvillea are common examples of ornamental plants that are frequently and successfully propagated using this reliable and effective technique.

284. (B) Vascular bundles arranged in a ring (eustele).
Dicot stems can be identified by their organized internal structure, where the vascular bundles are arranged in a concentric ring, a pattern known as a eustele. These bundles are typically conjoint, collateral, and open, containing a cambium that allows for secondary growth. This arrangement surrounds a central pith and is distinct from the scattered vascular bundle distribution found in the stems of monocotyledonous plant species.

285. (D) I, II, and III
Periderm is a multi-layered protective tissue that replaces the epidermis during secondary growth. It is formed by the activity of the phellogen, or cork cambium. The phellogen divides to produce phellem, or cork, toward the exterior of the plant and phelloderm, or secondary cortex, toward the interior. Together, these three layers provide insulation, prevent excessive water loss, and protect the internal tissues of the stem and root.

286. (D) node; axil
In plant morphology, the point on a stem where a leaf is attached is called a node. The angle formed between the upper side of the leaf base and the stem is known as the axil. It is within this axil that a bud, called an axillary bud, is typically located. This bud has the potential to develop into a lateral branch, a flower, or a specialized shoot structure.

287. (A) Sepal, Sepal, Carpel, Carpel
According to the ABC model of floral development, B-class genes are required to specify petals and stamens. If B-function is lost, the second whorl expresses only A-class genes, resulting in sepals. Similarly, the third whorl expresses only C-class genes, resulting in carpels. Therefore, a mutant flower lacking B-function would exhibit a sequence of organs consisting of two whorls of sepals followed by two whorls of carpels.

288. (B) Sporopollenin
Sporopollenin is an extraordinarily durable polymer that forms the primary component of the pollen grain's outer layer, or exine. It is recognized as one of the most chemically resistant biological materials known to science, capable of withstanding extreme temperatures, strong acids, and enzymatic degradation. This resistance is crucial for protecting the male gametes during their journey from the anther to the stigma across various environmental conditions.

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289. (B) Mesogamy
Mesogamy is a term used to describe a specific pathway taken by the pollen tube as it enters the ovule. In this process, the pollen tube penetrates the ovule through its integuments or via the funicle rather than through the micropyle or the chalaza. This is one of three main ways pollen tubes reach the female gametophyte, with the others being porogamy and chalazogamy, depending on the plant.

290. (A) Dry dehiscent
Dry dehiscent fruits are those that have a dry pericarp at maturity and possess a specialized mechanism to split open and release their seeds. This dehiscence can occur along one or more sutures or through pores. Common examples include legumes, capsules, and follicles. This strategy facilitates seed dispersal by using mechanical tension or environmental triggers to eject seeds away from the parent plant for better survival.

291. (C) Black pepper
While the nucellus is usually consumed during seed development, in some species, a portion of it remains as a persistent nutritive tissue called perisperm. Black pepper is a classic example of

41. Consider the following statements about plant hormones.
I. Abscisic acid (ABA) is often called the "stress hormone."
II. Auxins are primarily transported in a polar, basipetal direction.
III. Cytokinins are synthesized mainly in the root tips.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II only
(C) I and III only
(D) All I, II, and III

42. The conversion of nitrate (NO3-) to nitrite (NO_2-) in plants is catalyzed by the enzyme:
(A) Nitrate reductase
(B) Nitrite reductase
(C) Nitrogenase
(D) Glutamine synthetase

43. Which of the following statements about senescence is incorrect?
(A) It is a genetically programmed degenerative process.
(B) Ethylene and abscisic acid are known to promote senescence.
(C) Cytokinins can delay the onset of senescence in leaves.
(D) It is an entirely unregulated process of decay.

44. The biosynthesis of cytokinins involves a derivative of which molecule?
(A) Tryptophan
(B) Adenine
(C) Methionine
(D) Terpenoid precursors

45. The mechanism of action of many plant hormones involves:
(A) Direct metabolic catalysis.
(B) Primary cellular energy use.
(C) Receptor binding cascades.
(D) Structural wall alteration.

46. Which photoreceptor is primarily responsible for sensing red and far-red light to control processes like seed germination and flowering?
(A) Cryptochrome
(B) Phototropin
(C) Zeaxanthin
(D) Phytochrome

47. Phototropism, the bending of a plant towards a light source, is mediated primarily by which photoreceptor?
(A) Phototropin
(B) Phytochrome
(C) Cryptochrome
(D) Chlorophyll

48. Arrange the following steps of phytochrome-mediated signal transduction in the correct sequence.
I. Conformational change from Pr to Pfr form
II. Light absorption by the chromophore
III. Translocation of Pfr to the nucleus
IV. Regulation of gene expression
(A) II, I, III, IV
(B) I, II, IV, III
(C) II, III, I, IV
(D) IV, III, II, I

49. The biological clock in plants refers to:
(A) The mechanism that tracks the total hours of sunlight in a day.
(B) An internal, endogenous oscillator that controls circadian rhythms.
(C) The process of flowering in response to day length.
(D) The light-sensitive pigment that absorbs blue light.

50. Given below are two statements:
Statement I: Photoperiodism is the physiological response of organisms to the length of the day or night.
Statement II: Long-day plants flower only when the light period is longer than a certain critical length.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

51. Match List I with List II regarding sensory photobiology.
List I: (Photoreceptor)
P. Phytochrome
Q. Cryptochrome
R. Phototropin

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Which of the above statement(s) is/are correct?
(A) I only
(B) II and III only
(C) I and III only
(D) All I, II, and III

94. The loading of sucrose from companion cells into sieve-tube elements against a concentration gradient is an example of:
(A) Symplastic loading
(B) Facilitated diffusion
(C) Bulk flow
(D) Apoplastic loading

95. Which of the following is a correct statement regarding mineral nutrition?
(A) Nitrogen is a component of nucleic acids, proteins, and chlorophyll.
(B) Molybdenum is a macronutrient involved in chlorophyll structure.
(C) Magnesium is a micronutrient required as a cofactor for many enzymes.
(D) Calcium is highly mobile within the phloem.

96. Match List I with List II concerning mineral nutrients and their functions.
List I: (Nutrient)
P. Nitrogen
Q. Phosphorus
R. Potassium
S. Magnesium
List II: (Function)
1. Central atom of the chlorophyll molecule
2. Regulation of stomatal opening and closing
3. Component of ATP and nucleic acids
4. Component of amino acids and proteins
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-1, Q-3, R-2, S-4

97. The capture of light energy in photosynthesis is directly performed by:
(A) RuBisCO
(B) Pigment molecules like chlorophyll and carotenoids
(C) ATP synthase
(D) The thylakoid membrane itself

98. In the Z-scheme of photosynthetic electron transport, electrons from Photosystem II are transferred to Photosystem I via:
(A) Plastoquinone and the cytochrome b6f complex
(B) Ferredoxin
(C) NADP+ reductase
(D) Water

99. The main difference between C3 and C4 plants lies in their:
(A) Type of chlorophyll used.
(B) Mechanism of ATP synthesis.
(C) Initial CO_2 fixation step and leaf anatomy.
(D) Location of glycolysis.

100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Photorespiration is a metabolically wasteful process that reduces the efficiency of photosynthesis in C3 plants.
Reason (R): It consumes ATP and NADH, and releases previously fixed CO_2.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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101. Which of the following is NOT a phase of the Calvin cycle (C3 cycle)?
(A) Carboxylation
(B) Reduction
(C) Regeneration
(D) Oxidation

102. Given below are two statements:
Statement I: The chemiosmotic hypothesis explains ATP synthesis in both chloroplasts and mitochondria.
Statement II: In both organelles, an electron transport chain generates a proton gradient that drives ATP synthase.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

(B) II and III only
(C) I and III only
(D) All I, II, and III

62. Plants respond to insect herbivory by producing various compounds. Which of the following is a mechanism of resistance to insects?
(A) Increasing leaf sugar for palatability.
(B) Reducing the thickness of the cuticle.
(C) Opening stomata for transpiration.
(D) Emitting volatiles to attract predators.

63. The hypersensitive response (HR) in plants is a mechanism of resistance against pathogens that typically involves:
(A) Rapid, localized cell death at the site of infection.
(B) Systemic acquired resistance throughout the plant.
(C) The production of nectar to attract pollinators.
(D) Increased plant growth and vigor.

64. Given below are two statements:
Statement I: Abiotic stresses are caused by non-living factors like drought, salinity, and extreme temperatures.
Statement II: Biotic stresses are caused by living organisms like pathogens and insects.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

65. A plant's ability to maintain its physiological functions and survive under prolonged water deficit is best termed as:
(A) Water stress avoidance
(B) Drought tolerance
(C) Salt tolerance
(D) Heat shock response

66. Which hormone plays a central role in mediating stomatal closure during water stress?
(A) Abscisic acid (ABA)
(B) Auxin
(C) Gibberellin
(D) Ethylene

67. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): High salinity in soil creates a low water potential, making it difficult for plants to absorb water.
Reason (R): In addition to the osmotic stress, high concentrations of ions like Na^+ can be toxic to plant cells.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

68. The production of phytoalexins is a plant defense response primarily associated with:
(A) Resistance to abiotic stress.
(B) Regulation of flowering time.
(C) Enhancement of photosynthesis.
(D) Resistance to biotic stress (pathogens).

69. Which of the following is a common mechanism of salt tolerance in halophytes (salt-tolerant plants)?
(A) Preventing any salt from entering the roots.
(B) Increasing the rate of transpiration to excrete salt.
(C) Compartmentalizing excess salt in the vacuole.
(D) Converting salt into essential nutrients.

70. The general term for a molecule that binds to the active site of an enzyme and participates in the reaction is:
(A) Allosteric regulator
(B) Substrate
(C) Product
(D) Inhibitor

71. Match List I with List II concerning enzyme classification.
List I: (Enzyme Class)
P. Oxidoreductases
Q. Transferases
R. Hydrolases
S. Lyases
List II: (Reaction Catalyzed)
1. Catalyze cleavage by addition of water
2. Catalyze group transfer reactions

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(D) Systemic acquired resistance

136. An enzyme's activity is often affected by pH because:
(A) Changes in pH can alter the ionization state of amino acid residues in the active site.
(B) pH directly affects the substrate concentration.
(C) High pH provides more energy for the reaction.
(D) Low pH increases the Vmax of all enzymes.

137. Which of the following correctly pairs a class of biomolecules with its primary function?
(A) Carbohydrates - Catalysis of biochemical reactions
(B) Proteins - Long-term energy storage
(C) Nucleic Acids - Information storage and transfer
(D) Lipids - Structural support in the cell wall

138. The role of terpenes like menthol and limonene in plants is often related to:
(A) Defense against herbivores and pathogens.
(B) Acting as primary photosynthetic pigments.
(C) Serving as structural components of the cell wall.
(D) Long-distance transport of sugars.

139. Flavonoids, a class of phenolic compounds, are responsible for many of the red, blue, and purple colors in flowers and fruits. Their role is often to:
(A) Attract pollinators and seed dispersers.
(B) Provide structural support to the stem.
(C) Store nitrogen for later use.
(D) Inhibit plant growth.

140. Which of the following statements about nitrogenous secondary metabolites is incorrect?
(A) They include important compounds like alkaloids and cyanogenic glycosides.
(B) They are synthesized from amino acid precursors.
(C) They are considered primary metabolites essential for all plant life.
(D) They often function in plant defense.

141. Water movement across the plasma membrane of a plant cell is facilitated by proteins called:
(A) Ion channels
(B) Aquaporins
(C) ATPases
(D) Lectins

142. The cohesion-tension theory explains the ascent of sap in xylem. The "cohesion" part refers to the:
(A) Attraction of water molecules to the xylem walls.
(B) Attraction of water molecules to each other.
(C) Force generated by root pressure.
(D) Evaporation of water from leaf surfaces.

143. A plant physiologist observes that a particular nutrient deficiency causes chlorosis in the older, lower leaves first. This indicates that the nutrient is:
(A) Mobile in the phloem
(B) Immobile in the phloem
(C) A micronutrient
(D) Required for root growth only

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144. In C4 photosynthesis, CO_2 is first fixed into a 4-carbon acid in the _____ cells and then transported to the _____ cells where the Calvin cycle occurs.
(A) bundle sheath; mesophyll
(B) mesophyll; bundle sheath
(C) epidermal; mesophyll
(D) bundle sheath; guard

145. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cyclic electron flow in photosynthesis produces ATP but not NADPH.
Reason (R): It is thought to supplement ATP production when the Calvin cycle's demand for ATP is higher than for NADPH.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

146. A major difference between respiration and photorespiration is that:
(A) Respiration occurs in all living cells, while photorespiration occurs only in photosynthetic cells in the light.
(B) Respiration fixes CO_2, while photorespiration

II. Loading of sucrose into the sieve tube at the source
III. Bulk flow from source to sink due to a pressure gradient
IV. Water enters the sieve tube by osmosis, increasing turgor pressure
(A) II, IV, III, I
(B) I, II, III, IV
(C) II, I, IV, III
(D) IV, II, I, III

84. Terpenes are a large and diverse class of secondary metabolites synthesized from which basic five-carbon precursor unit?
(A) Phenylalanine
(B) Acetyl-CoA
(C) Shikimic acid
(D) Isopentenyl diphosphate (IPP)

85. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The mevalonic acid (MVA) pathway is a key route for terpene biosynthesis in plants.
Reason (R): All terpenes are nitrogen-containing compounds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

86. Phenolic compounds in plants, such as flavonoids and lignins, are primarily biosynthesized via the:
(A) Mevalonic acid pathway
(B) Shikic acid pathway
(C) Glycolysis pathway
(D) Citric acid cycle

87. Which of the following is a major role of phenolic compounds like lignin in plants?
(A) Energy storage
(B) Photosynthesis
(C) Nitrogen fixation
(D) Structural support and defense

88. Alkaloids are a group of nitrogenous secondary metabolites known for their potent physiological effects. Which of the following is a well-known alkaloid?
(A) Morphine
(B) Menthol
(C) Carotene
(D) Lignin

89. Given below are two statements:
Statement I: Secondary metabolites are essential for the basic metabolic processes of growth and development in all plants.
Statement II: Secondary metabolites often play roles in defense, attraction of pollinators, and allelopathy.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

90. The biosynthesis of many nitrogenous secondary metabolites, such as alkaloids, often originates from:
(A) Amino acids
(B) Carbohydrates
(C) Lipids
(D) Terpenes

91. The solute potential of a plant cell is always:
(A) Positive or zero
(B) Equal to the pressure potential
(C) Equal to the water potential
(D) Negative or zero

92. Translocation of solutes across a membrane against their concentration gradient requires:
(A) Channel proteins and is a form of passive transport.
(B) Carrier proteins and metabolic energy.
(C) Simple diffusion without any protein involvement.
(D) The presence of a semipermeable membrane only.

93. Consider the following statements about the mechanism of stomatal movement.
I. The accumulation of K^+ ions in guard cells lowers their water potential.
II. Blue light is an effective signal for stomatal opening.
III. Abscisic acid (ABA) promotes stomatal closure.

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115. A non-competitive inhibitor of an enzyme:
(A) Binds to the active site and competes with the substrate.
(B) Binds to a site other than the active site and changes the enzyme's conformation.
(C) Increases the Vmax of the reaction.
(D) Decreases the Km of the enzyme for its substrate.

116. Which of the following describes the induced-fit model of enzyme-substrate interaction?
(A) The enzyme has a rigid active site that perfectly fits the substrate.
(B) The binding of the substrate induces a conformational change in the enzyme's active site.
(C) The substrate changes its shape to fit the rigid active site of the enzyme.
(D) The enzyme and substrate are covalently bonded before the reaction begins.

117. Arrange the following steps in the biosynthesis of flavonoids (a class of phenols) in the correct order.
I. Synthesis of Phenylalanine
II. Formation of Chalcone
III. Shikimic acid pathway
IV. Action of Chalcone synthase
(A) III, I, IV, II
(B) I, III, II, IV
(C) III, II, I, IV
(D) I, IV, III, II

118. Which statement correctly identifies the structure and function of a biomolecule?
(A) Cellulose is a branched polysaccharide providing structural support in plant cell walls.
(B) DNA is a single-stranded nucleic acid involved in protein synthesis.
(C) Hemoglobin is a fibrous protein responsible for muscle contraction.
(D) Phospholipids are amphipathic lipids that form the bilayer of cell membranes.

119. The biosynthesis of rubber, a polyterpene, primarily occurs through which pathway?
(A) Shikimic acid pathway
(B) Mevalonic acid pathway
(C) Glyoxylate cycle
(D) Pentose phosphate pathway

120. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Many secondary metabolites, such as alkaloids and terpenes, serve as defense compounds against herbivores.
Reason (R): These compounds are often toxic or unpalatable, deterring feeding.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

121. What is the driving force for water movement from the soil into the root xylem?
(A) A water potential gradient
(B) Active transport of water molecules
(C) The pressure-flow mechanism
(D) Phloem loading

122. Given below are two statements:
Statement I: The Casparian strip in the endodermis blocks the apoplastic pathway for water and solutes.
Statement II: This blockage forces water and solutes to cross a membrane, allowing for selective uptake.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

123. The "unloading" of photoassimilates at a sink tissue like a root or fruit can occur:
(A) Only through the apoplastic pathway.
(B) Only through the symplastic pathway.
(C) Through either symplastic or apoplastic pathways, depending on the sink type.
(D) Only when the sink is actively photosynthesizing.

124. Which of the following is a symptom of nitrogen deficiency in plants?
(A) Stunted growth and general chlorosis, especially in older leaves.
(B) Necrotic spots on young leaves.
(C) Dark green foliage with purple discoloration.
(D) Interveinal chlorosis in young leaves.

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103. A key regulatory step in glycolysis is the phosphorylation of fructose-6-phosphate to fructose-1,6-bisphosphate, catalyzed by:
(A) Hexokinase
(B) Aldolase
(C) Phosphofructokinase
(D) Pyruvate kinase

104. The complete oxidation of one molecule of acetyl-CoA in the citric acid cycle yields:
(A) 1 CO_2, 2 ATP (or GTP), 2 NADH, 2 FADH2
(B) 3 CO_2, 1 ATP (or GTP), 4 NADH, 0 FADH2
(C) 2 CO_2, 2 ATP (or GTP), 3 NADH, 1 FADH2
(D) 2 CO_2, 1 ATP (or GTP), 3 NADH, 1 FADH2

105. The primary purpose of the assimilation of nitrate and ammonium in plants is the synthesis of:
(A) Amino acids
(B) Carbohydrates
(C) Lipids
(D) Secondary metabolites

106. A plant scientist applies a substance to a dwarf plant, and it grows to a normal height. The substance most likely contained:
(A) Abscisic acid
(B) Ethylene
(C) Gibberellin
(D) Cytokinin

107. The breakdown and transport of molecules from a senescing leaf is an ordered process. Which of the following is mobilized LAST from a dying leaf?
(A) Proteins
(B) Chlorophyll
(C) Mobile mineral nutrients like Nitrogen and Phosphorus
(D) Structural components like calcium

108. The mechanism of polar auxin transport involves:
(A) Cell membrane diffusion.
(B) Xylem vessel transport.
(C) Efflux carrier proteins.
(D) Phloem sieve movement.

109. Which of the following is an incorrect statement about phytochrome?
(A) It exists in two photo-interconvertible forms, Pr and Pfr.
(B) The Pr form absorbs red light and is converted to the Pfr form.
(C) The Pfr form is the biologically active form.
(D) Pfr is converted to Pr by exposure to far-red light or by synthesis in the dark.

110. A day-neutral plant:
(A) Flowers regardless of the day length.
(B) Flowers only when days are short.
(C) Flowers only when days are long.
(D) Requires a cold treatment to flower.

111. Consider the following statements about sensory photobiology.
I. Phytochromes, cryptochromes, and phototropins are all photoreceptors in plants.
II. Cryptochromes are primarily involved in sensing red and far-red light.
III. Phototropins mediate stomatal opening in response to blue light.
Which of the above statement(s) is/are correct?
(A) I and III only
(B) II and III only
(C) I only
(D) All I, II, and III

112. The circadian rhythm of leaf movement in plants, known as nyctinasty, is controlled by:
(A) Phototropism
(B) The biological clock
(C) Vernalization
(D) Gravitropism

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113. A plant's response to water stress by developing a deeper root system is an example of:
(A) A resistance mechanism
(B) An avoidance/acclimation mechanism
(C) A biotic stress response
(D) A hypersensitive response

114. The term "Systemic Acquired Resistance" (SAR) refers to a plant-wide resistance response that:
(A) Is triggered by an initial localized pathogen attack.
(B) Is effective only against the specific pathogen that caused the initial infection.
(C) Is a response to abiotic stress like drought.
(D) Involves the production of large quantities of nectar.

3. Catalyze cleavage of bonds by elimination, leaving double bonds
4. Catalyze oxidation-reduction reactions

(A) P-3, Q-1, R-4, S-2
(B) P-4, Q-2, R-1, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-3, S-1

72. According to the Michaelis-Menten kinetics, the Michaelis constant (Km) is defined as:
(A) The substrate concentration at which the reaction velocity is half of the maximum.
(B) The maximum velocity of the reaction.
(C) The turnover number of the enzyme.
(D) The concentration of the enzyme-substrate complex.

73. A competitive inhibitor binds to which site on an enzyme?
(A) An allosteric site
(B) The substrate itself
(C) The active site
(D) The product of the reaction

74. Consider the following statements about allosteric regulation.
I. Allosteric enzymes often have multiple subunits.
II. Allosteric regulators bind to the active site of the enzyme.
III. The binding of an allosteric activator increases the enzyme's activity.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) All I, II, and III

75. The fundamental repeating unit of a protein is:
(A) A nucleotide
(B) A monosaccharide
(C) A fatty acid
(D) An amino acid

76. Which of the following is a polysaccharide used for energy storage in plants?
(A) Glycogen
(B) Starch
(C) Chitin
(D) Cellulose

77. Given below are two statements:
Statement I: Lipids are a diverse group of hydrophobic molecules.
Statement II: Phospholipids are the primary components of plant cell walls.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

78. The bond that links amino acids together to form a polypeptide chain is called a:
(A) Glycosidic bond
(B) Phosphodiester bond
(C) Hydrogen bond
(D) Peptide bond

79. Which of the following is a purine base found in nucleic acids?
(A) Guanine
(B) Cytosine
(C) Thymine
(D) Uracil

80. Vitamins are best described as:
(A) Major energy-yielding macronutrients.
(B) Organic molecules required in small amounts, often acting as coenzymes.
(C) Inorganic elements required in small amounts.
(D) The building blocks of proteins.

81. The secondary structure of a protein, such as an alpha-helix or beta-sheet, is stabilized primarily by:
(A) Peptide bonds
(B) Hydrogen bonds between backbone atoms
(C) Disulfide bridges
(D) Hydrophobic interactions

82. Which of the following is an incorrect pair of a biomolecule and its monomer?
(A) Lipid - Monosaccharide
(B) Protein - Amino acid
(C) Starch - Glucose
(D) Nucleic Acid - Nucleotide

83. Arrange the following steps in the pressure-flow model for phloem translocation in correct chronological order:
I. Unloading of sucrose at the sink

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125. The mechanism of electron transport in photosynthesis leads to the generation of which two high-energy molecules?
(A) ATP and NADPH
(B) ATP and Glucose
(C) NADPH and FADH2
(D) CO_2 and ATP

126. Match List I with List II regarding the photosynthetic pathways.
List I: (Plant Type / Process)
P. C3 Plant (e.g., Rice)
Q. C4 Plant (e.g., Maize)
R. CAM Plant (e.g., Pineapple)
S. Photorespiration
List II: (Characteristic)
1. Kranz anatomy present
2. Temporal separation of CO_2 fixation and Calvin cycle
3. CO_2 fixation directly by RuBisCO in mesophyll cells
4. Occurs at high rates in hot, dry conditions
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-3, S-4

127. Which of the following statements about the citric acid cycle is incorrect?
(A) It is also known as the Krebs cycle.
(B) It is the central metabolic hub of the cell.
(C) It directly consumes oxygen.
(D) It generates reducing equivalents (NADH, FADH2) for the electron transport chain.

128. Cyanide is a potent inhibitor of cellular respiration because it binds to and inhibits:
(A) ATP synthase
(B) Complex IV (cytochrome c oxidase) of the electron transport chain
(C) Pyruvate dehydrogenase
(D) Succinate dehydrogenase

129. The synthesis of amino acids in plants requires a carbon skeleton and an amino group. The carbon skeletons are primarily derived from:
(A) Intermediates of photosynthesis and respiration.
(B) The breakdown of secondary metabolites.
(C) The fixation of atmospheric CO_2 only.
(D) The breakdown of lipids only.

130. The "acid growth" hypothesis of auxin action proposes that auxin:
(A) Stimulates meristem cell division.
(B) Activates wall-loosening enzymes.
(C) Promotes gibberellin synthesis.
(D) Increases cellular solute uptake.

131. Consider the following statements regarding plant hormones.
I. Ethylene is a gaseous hormone that promotes fruit ripening.
II. Abscisic acid promotes seed dormancy and stomatal closure.
III. Gibberellins and auxins often act synergistically to promote stem growth.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I only
(D) All I, II, and III

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132. The photoreversible nature of phytochrome is key to its function. The form that is considered biologically inactive and accumulates in the dark is:
(A) Pfr
(B) Pr
(C) Pox (oxidized phytochrome)
(D) Pbl (blue-light absorbing phytochrome)

133. The measurement of time in photoperiodism is based on:
(A) The length of the light period.
(B) The length of the uninterrupted dark period.
(C) The total amount of light energy received.
(D) The ratio of red to far-red light at dawn.

134. Which of the following is NOT a function mediated by blue-light photoreceptors (cryptochromes and phototropins)?
(A) Phototropism
(B) Stomatal opening
(C) Shade avoidance response
(D) Inhibition of hypocotyl elongation

135. A plant that can survive in a high-salt environment by excluding salt from its roots or secreting it from salt glands is exhibiting:
(A) Salt tolerance
(B) Salt avoidance
(C) A hypersensitive response

S. Chlorophyll

List II: (Primary Light Absorbed)

1. Blue and UVA light
2. Red and far-red light
3. Blue and red light
4. Blue light

(A) P-1, Q-4, R-3, S-2
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-4, S-2

52. Vernalization refers to the:
(A) Bending of a plant stem towards light.
(B) Inhibition of germination by far-red light.
(C) Daily cycle of leaf movements.
(D) Induction of flowering by exposure to prolonged cold temperatures.

53. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The active form of phytochrome is Pfr (far-red absorbing).
Reason (R): Exposure to red light converts the inactive Pr form to the active Pfr form, which can then initiate a physiological response.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

54. Which of the following is NOT a characteristic of a biological clock?
(A) It is endogenous and self-sustaining.
(B) It stops completely in the absence of an external light cue.
(C) It can be reset or entrained by external cues like light.
(D) Its period is temperature-compensated.

55. The chromophore part of the phytochrome molecule, which absorbs light, is a:
(A) Flavin
(B) Carotenoid
(C) Heme group
(D) Linear tetrapyrrole

56. Cryptochromes are flavoproteins that are involved in all of the following processes EXCEPT:
(A) Sensing gravity
(B) De-etiolation
(C) Entrainment of the circadian clock
(D) Phototropism

57. A short-day plant will flower if:
(A) The day length is shorter than a critical maximum.
(B) The night period is interrupted by a brief flash of light.
(C) The night length is longer than a critical minimum.
(D) The day length is longer than a critical minimum.

58. The perception of the photoperiodic stimulus for flowering occurs in the:
(A) Leaves
(B) Roots
(C) Apical meristem
(D) Flowers

59. Which statement incorrectly describes the mechanism of action of phototropins?
(A) Phototropins are plasma membrane-associated kinases.
(B) They undergo autophosphorylation upon blue light absorption.
(C) They mediate the redistribution of auxin, leading to differential growth.
(D) They are primarily responsible for detecting red light.

60. The ability of a plant to resist a pathogen by activating defense mechanisms is known as:
(A) Acclimation
(B) Resistance
(C) Susceptibility
(D) Tolerance

61. Consider the following plant responses to stress.
I. Production of heat-shock proteins in response to high temperature.
II. Accumulation of compatible solutes like proline in response to water stress.
III. Closure of stomata in response to salt stress.
Which of the above statement(s) is/are correct?
(A) I and II only

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releases CO_2.
(C) Respiration produces ATP, while photorespiration consumes ATP.
(D) All of the above.

147. Given below are two statements:
Statement I: The final product of glycolysis is acetyl-CoA.
Statement II: The link reaction (pyruvate oxidation) converts pyruvate into acetyl-CoA.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

148. The GS-GOGAT pathway is a high-affinity pathway for ammonium assimilation. What does GOGAT stand for?
(A) Glutamine-Oxaloacetate Aminotransferase
(B) Glycine-Oxoglutarate Aminotransferase
(C) Glutamate synthase
(D) Glucose-6-Phosphate Oxoglutarate

149. The phenomenon of apical dominance is maintained by a high concentration of _____ produced in the apical bud, which inhibits the growth of _____ buds.
(A) auxin; lateral
(B) cytokinin; terminal
(C) gibberellin; axillary
(D) ethylene; adventitious

150. Arrange the following events in the perception of a cold stimulus for vernalization:
I. Flowering is promoted later in the season.
II. Plant is exposed to a prolonged period of low temperature.
III. A stable epigenetic change occurs at flowering-locus C (FLC).
IV. The meristem becomes competent to flower.
(A) II, III, IV, I
(B) I, II, III, IV
(C) II, IV, I, III
(D) III, II, I, IV

151. Match List I with List II regarding plant hormones.
List I: (Hormone)
P. Auxin
Q. Cytokinin
R. Gibberellin
S. Abscisic Acid
List II: (A primary function)
1. Promotes seed germination and stem elongation
2. Promotes cell division
3. Promotes stomatal closure and dormancy
4. Promotes apical dominance and cell elongation
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-3, S-1

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152. Which of the following is a classic example of a phytochrome-mediated "low fluence response"?
(A) Phototropism
(B) Red-light induced seed germination
(C) Stomatal opening
(D) Chloroplast migration

153. A plant experiencing heat stress will likely synthesize which type of proteins to protect and refold other proteins?
(A) Pathogenesis-related (PR) proteins
(B) Heat-shock proteins (HSPs)
(C) Dehydrins
(D) Lectins

154. What is the effect of a competitive inhibitor on the Michaelis-Menten kinetics of an enzyme?
(A) Vmax is decreased, Km is unchanged.
(B) Vmax is unchanged, Km is increased.
(C) Vmax is decreased, Km is decreased.
(D) Both Vmax and Km are unchanged.

155. Which of the following is a monosaccharide?
(A) Sucrose
(B) Lactose
(C) Fructose
(D) Starch

156. The nitrogenous base uracil is found in _____ instead of thymine, which is found in _____.
(A) DNA; RNA
(B) RNA; DNA
(C) proteins; lipids
(D) RNA; proteins

157. The biosynthesis of alkaloids, which are nitrogen-containing secondary metabolites,

(B) Solute potential gradient between xylem and phloem.
(C) Water potential gradient created by transpiration.
(D) Concentration gradient of K^+ ions.

242. Deficiency of which mineral element, a component of chlorophyll, leads to chlorosis?
(A) Potassium (K)
(B) Phosphorus (P)
(C) Magnesium (Mg)
(D) Calcium (Ca)

243. The light-harvesting complexes (LHCs) consist of:
(A) ATP synthase and RuBisCO.
(B) Proteins and pigment molecules like chlorophyll and carotenoids.
(C) Electron transport chain components only.
(D) Enzymes of the Calvin cycle.

244. A plant that is adapted to a hot, dry environment and fixes CO_2 into a 4-carbon compound in the mesophyll has which photosynthetic pathway?
(A) C3
(B) C4
(C) CAM
(D) Photorespiration

245. Match List I with List II concerning respiration.
List I: (Stage)
P. Glycolysis
Q. Link Reaction
R. Citric Acid Cycle
S. Electron Transport Chain
List II: (Primary Location)
1. Mitochondrial Matrix
2. Cytosol
3. Inner Mitochondrial Membrane
4. From Cytosol to Mitochondrial Matrix
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-1, R-2, S-4

246. The assimilation of ammonium (NH_4^+) into organic form is essential for plant growth. The two primary pathways for this are the GDH pathway and the:
(A) MVA pathway
(B) GS-GOGAT pathway
(C) Shikic acid pathway
(D) Pentose phosphate pathway

247. The "triple response" of seedlings to ethylene is a classic bioassay for this hormone. The three responses are:
(A) Stem elongation, leaf expansion, and flowering.
(B) Inhibition of elongation, radial swelling of the stem, and exaggerated apical hook.
(C) Greening, root branching, and seed germination.
(D) Apical dominance, fruit ripening, and leaf abscission.

248. The photoreceptor responsible for phototropism, chloroplast movement, and stomatal opening is:
(A) Phytochrome
(B) Phototropin
(C) Cryptochrome
(D) Chlorophyll a

249. A plant's response to drought stress includes the synthesis and accumulation of a hormone that induces stomatal closure. This hormone is:
(A) Gibberellin
(B) Cytokinin
(C) Abscisic acid (ABA)
(D) Auxin

250. How does a non-competitive inhibitor affect the kinetic parameters of an enzyme-catalyzed reaction?
(A) It increases Km but does not affect Vmax.
(B) It decreases Vmax but does not affect Km.
(C) It decreases both Vmax and Km.
(D) It increases both Vmax and Km.

251. Which of the following is composed of nucleotides?
(A) An enzyme
(B) A starch molecule
(C) A messenger RNA (mRNA) molecule
(D) A triglyceride

252. The function of many terpenes and phenolic compounds in plant-herbivore interactions is primarily:
(A) Nutritional
(B) Defensive
(C) Structural

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168. You are given two plants. Plant A has its apical bud intact, while Plant B has its apical bud removed. Which of the following outcomes is most likely?
(A) Plant A will show more lateral branching than Plant B.
(B) Plant B will show more lateral branching than Plant A.
(C) Both plants will grow identically.
(D) Plant B will stop growing entirely.

169. Given below are two statements:
Statement I: Senescence is an active, energy-requiring, and genetically programmed process in plants.
Statement II: Senescence allows for the efficient recycling of nutrients from older organs to younger, growing parts of the plant.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

170. Which hormone is biosynthesized from the amino acid methionine?
(A) Auxin
(B) Cytokinin
(C) Ethylene
(D) Abscisic acid

171. A key feature of the biological clock mechanism is temperature compensation. This means that:
(A) The clock runs faster at higher temperatures.
(B) The clock runs slower at lower temperatures.
(C) The period of the clock remains relatively constant over a range of physiological temperatures.
(D) The clock only functions at a specific optimal temperature.

172. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Interrupting a long night with a flash of red light can induce flowering in a long-day plant.
Reason (R): The flash of red light converts Pr to Pfr, making the plant perceive the night as being short.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

173. The initial response of a plant to pathogen attack often involves the recognition of Pathogen-Associated Molecular Patterns (PAMPs). This recognition leads to:
(A) PAMP-triggered immunity (PTI)
(B) Effector-triggered immunity (ETI)
(C) Systemic acquired resistance (SAR)
(D) The hypersensitive response (HR)

174. To cope with salt stress, some plants accumulate high concentrations of inorganic ions in the vacuole. To maintain osmotic balance in the cytoplasm, they synthesize and accumulate:
(A) Toxic secondary metabolites
(B) Compatible solutes or osmolytes
(C) Heat-shock proteins
(D) Saturated fatty acids

175. The tertiary structure of a protein is primarily determined by:
(A) The sequence of amino acids.
(B) Interactions between the R-groups of the amino acids.
(C) The number of polypeptide chains.
(D) The presence of prosthetic groups.

176. Which of the following is an example of a structural polysaccharide?
(A) Starch
(B) Glycogen
(C) Cellulose
(D) Sucrose

177. Match List I with List II regarding biomolecules.
List I: (Biomolecule)
P. Protein
Q. DNA
R. Starch
S. Phospholipid
List II: (Defining Feature/Bond)
1. Double helix structure
2. Amphipathic nature
3. Peptide bond
4. Glycosidic bond
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-4, S-2

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(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-1, S-3

178. What is the effect of an allosteric inhibitor on an enzyme?
(A) It binds to the active site directly.
(B) It causes conformation changes.
(C) It modifies the enzyme structure.
(D) It increases substrate affinity.

179. The isoprene unit (C5) is the building block for all terpenes. Which of the following is a C10 terpene (monoterpene)?
(A) Gibberellin
(B) Carotenoid
(C) Menthol
(D) Rubber

180. The shikimic acid pathway is crucial for the biosynthesis of:
(A) Terpenes and steroids
(B) Aromatic amino acids and phenolic compounds
(C) Fatty acids and lipids
(D) Alkaloids and cyanogenic glycosides

181. The water potential (Ψw) of a solution in an open beaker is determined primarily by its:
(A) Solute potential (Ψs)
(B) Pressure potential (Ψp)
(C) Matrix potential (Ψm)
(D) Temperature

182. Which of the following pairs of transport mechanisms and their properties is incorrect?
(A) Simple Diffusion - No protein carrier, follows concentration gradient
(B) Facilitated Diffusion - Protein carrier, follows concentration gradient
(C) Active Transport - Protein carrier, requires energy, against gradient
(D) Ion Channel - Protein carrier, requires energy, follows gradient

183. Arrange the following events of CO_2 fixation in a C4 plant in the correct order:
I. Decarboxylation of a 4-C acid in bundle sheath cells to release CO_2.
II. Fixation of CO_2 by RuBisCO in the Calvin cycle.
III. Fixation of HCO3- by PEP carboxylase in mesophyll cells.
IV. Transport of a 4-C acid to bundle sheath cells.
(A) III, IV, I, II
(B) I, II, III, IV
(C) III, I, IV, II
(D) IV, III, II, I

184. The photoprotective mechanism involving the dissipation of excess light energy as heat is known as:
(A) Non-photochemical quenching (NPQ)
(B) State transitions
(C) Cyclic electron flow
(D) The xanthophyll cycle

185. Which of the following is a substrate for the enzyme RuBisCO?
(A) PEP and CO_2
(B) Ribulose-1,5-bisphosphate and CO_2
(C) Malate and O_2
(D) 3-PGA and ATP

186. During cellular respiration, the majority of ATP is produced by which process?
(A) Glycolysis
(B) Oxidative phosphorylation
(C) Citric acid cycle
(D) Fermentation

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187. Which statement accurately describes the link between the citric acid cycle and the electron transport chain?
(A) The citric acid cycle uses ATP produced by the electron transport chain.
(B) The electron transport chain uses O_2 produced by the citric acid cycle.
(C) The citric acid cycle produces NADH and FADH2, which donate electrons to the electron transport chain.
(D) The citric acid cycle and the electron transport chain are physically located in the same compartment, the cytoplasm.

188. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Polar transport of auxin is a key process in establishing plant polarity and mediating tropic responses.
Reason (R): The asymmetric distribution of

auxin efflux carriers (PIN proteins) on the plasma membrane directs the flow of auxin from cell to cell.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

189. Which of the following is not a primary role of cytokinins?
(A) Promoting cell division (cytokinesis)
(B) Delaying leaf senescence
(C) Promoting lateral bud growth
(D) Inducing seed dormancy

190. What is the fundamental difference between photoperiodism and vernalization?
(A) Photoperiodism is a response to light, while vernalization is a response to gravity.
(B) Photoperiodism is a response to day length, while vernalization is a response to cold temperature.
(C) Photoperiodism controls germination, while vernalization controls flowering.
(D) Photoperiodism is mediated by phytochromes, while vernalization is mediated by cryptochromes.

191. Consider the following statements about plant photoreceptors.
I. Phototropins are flavoproteins that absorb blue light.
II. Phytochromes are biliproteins that perceive red/far-red light.
III. Cryptochromes are involved in setting the circadian clock.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I only
(D) All I, II, and III

192. Effector-Triggered Immunity (ETI) is a plant defense response characterized by:
(A) A general, non-specific response to common microbial molecules.
(B) A highly specific recognition of pathogen effector proteins by plant R (resistance) proteins.
(C) The accumulation of compatible solutes to combat osmotic stress.
(D) The synthesis of heat-shock proteins.

193. The denaturation of an enzyme refers to the:
(A) Loss of its primary structure.
(B) Loss of its secondary, tertiary, and quaternary structure and thus its function.
(C) Cleavage of its peptide bonds.
(D) Binding of a competitive inhibitor.

194. Which of the following statements about nucleic acids is correct?
(A) DNA contains the sugar ribose, while RNA contains deoxyribose.
(B) The two strands of a DNA double helix are parallel.
(C) Adenine pairs with thymine (in DNA) and guanine pairs with cytosine.
(D) The backbone of a nucleic acid is composed of repeating amino acids.

195. Sucrose, the primary sugar translocated in the phloem, is a disaccharide composed of:
(A) Two glucose units
(B) Glucose and fructose
(C) Glucose and galactose
(D) Two fructose units

196. The role of secondary metabolites in attracting pollinators is best exemplified by:
(A) The bitter taste of alkaloids.
(B) The structural rigidity of lignin.
(C) The color of flavonoids and the scent of terpenes in flowers.
(D) The toxicity of cyanogenic glycosides.

197. Which of the following is a nitrogenous compound that functions in defense by releasing hydrogen cyanide (HCN) upon tissue damage?
(A) Alkaloid
(B) Terpenoid
(C) Cyanogenic glycoside
(D) Flavonoid

198. The Casparian strip is a band of suberin and lignin found in the cell walls of which root tissue?
(A) Epidermis
(B) Cortex
(C) Endodermis

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from a substrate.
(B) The flow of protons down an electrochemical gradient through ATP synthase.
(C) The reduction of oxygen to water.
(D) The oxidation of glucose in glycolysis.

220. The breakdown of storage lipids in seeds is initiated by enzymes called lipases. The resulting fatty acids are then converted to sugars for the growing embryo via which two processes?
(A) Glycolysis and the Citric Acid Cycle
(B) Beta-oxidation and the Glyoxylate Cycle
(C) Photosynthesis and Photorespiration
(D) Fermentation and Gluconeogenesis

221. Consider the following statements about amino acid biosynthesis.
I. The carbon skeletons for amino acids are derived from intermediates of glycolysis and the citric acid cycle.
II. The nitrogen is incorporated primarily via the GS-GOGAT pathway.
III. All 20 common amino acids can be synthesized by plants.
Which of the above statement(s) is/are correct?
(A) I and III only
(B) II only
(C) I and II only
(D) All I, II, and III

222. The "greening" or de-etiolation of a dark-grown seedling exposed to light involves all of the following EXCEPT:
(A) Inhibition of hypocotyl elongation.
(B) Opening and expansion of the cotyledons.
(C) Synthesis of chlorophyll.
(D) Increased polar transport of auxin.

223. The function of phototropins in mediating stomatal opening is linked to:
(A) The perception of red light.
(B) The activation of a plasma membrane proton pump (H+-ATPase) in guard cells.
(C) The degradation of abscisic acid.
(D) The measurement of the dark period length.

224. Which of the following is a mechanism of tolerance (not avoidance) to biotic stress from an insect herbivore?
(A) Having tough, indigestible leaves.
(B) Producing toxic alkaloids.
(C) Having a high capacity for regrowth and compensation after being damaged.
(D) Producing volatile compounds that repel the insect.

225. A plot of initial reaction velocity (v0) versus substrate concentration [S] for an allosteric enzyme will typically show which shape?
(A) A hyperbolic curve
(B) A sigmoidal (S-shaped) curve
(C) A straight line with a positive slope
(D) A straight line with a negative slope

226. What distinguishes a saturated fatty acid from an unsaturated fatty acid?
(A) The presence of nitrogen atoms in the chain.
(B) The absence of carbon-carbon double bonds.
(C) Its ability to dissolve in water.
(D) The presence of a phosphate group.

227. Glucosinolates are nitrogen- and sulfur-containing secondary metabolites that function in plant defense, particularly in the Brassicaceae family. Their defensive action involves:
(A) Acting as potent signaling molecules.
(B) Providing structural reinforcement to cell walls.
(C) Breaking down upon tissue damage to release pungent and toxic compounds like isothiocyanates.
(D) Attracting pollinators with a sweet scent.

228. Unloading of photoassimilates from the phloem into a developing storage root is an example of transport to a:
(A) Source tissue
(B) Sink tissue
(C) Photosynthetic tissue
(D) Transpiring tissue

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229. Given below are two statements:
Statement I: Transpiration is an inevitable consequence of a plant's need to take up CO_2 for photosynthesis.
Statement II: The same pores (stomata) that allow CO_2 to enter the leaf also allow water vapor to exit.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.

(B) The accumulation of solutes in the cytoplasm to lower the freezing point.
(C) Generating metabolic heat through the alternative oxidase pathway.
(D) Migrating to warmer climates.

210. Match List I with List II regarding enzyme kinetics.
List I: (Term)
P. Vmax
Q. Km
R. Competitive Inhibition
S. Non-competitive Inhibition
List II: (Description)
1. Inhibitor binds to a site other than the active site
2. The maximum rate of reaction at substrate saturation
3. Substrate concentration at 1/2 Vmax
4. Inhibitor resembles the substrate and binds to the active site
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-3, R-4, S-2

211. Which of the following correctly describes a lipid?
(A) A complex polymer of amino acids providing various cellular functions.
(B) A long-chain carbohydrate used specifically for structural cell support.
(C) A group of hydrophobic molecules like fats, oils, and waxes.
(D) A molecule made of nucleotides that carries genetic information.

212. What is the role of vitamins in metabolism?
(A) Primary source of metabolic energy.
(B) Inorganic cofactors for enzyme sites.
(C) Coenzyme precursors for reactions.
(D) Protein and nucleic acid building blocks.

213. The mevalonic acid (MVA) and methylerythritol phosphate (MEP) pathways are two distinct routes for the biosynthesis of:
(A) Phenolic compounds
(B) Isoprenoid (terpenoid) precursors
(C) Alkaloids
(D) Amino acids

214. The 'source' in the context of phloem translocation is best defined as:
(A) Any part of the plant below the ground.
(B) A net exporter of photoassimilates.
(C) A net importer of photoassimilates.
(D) The part of the plant that absorbs water.

215. Consider a plant cell with $\Psi s = -0.9$ MPa and $\Psi p = 0.5$ MPa. What is its total water potential (Ψw)?
(A) -1.4 MPa
(B) +0.4 MPa
(C) -0.4 MPa
(D) +1.4 MPa

216. The enzyme nitrate reductase, crucial for nitrogen assimilation, contains which micronutrient as a cofactor?
(A) Zinc (Zn)
(B) Copper (Cu)
(C) Boron (B)
(D) Molybdenum (Mo)

217. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In C3 plants, high temperatures and high O_2 concentration promote photorespiration.
Reason (R): The enzyme RuBisCO has an increased affinity for O_2 relative to CO_2 at higher temperatures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

218. The regeneration phase of the Calvin cycle requires _____ to convert ribulose-5-phosphate into ribulose-1,5-bisphosphate.
(A) ATP
(B) NADPH
(C) CO_2
(D) FADH2

219. The chemiosmotic theory of ATP synthesis proposes that the energy to phosphorylate ADP comes from:
(A) The direct transfer of a phosphate group

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often utilizes precursors from which primary metabolic pathways?
(A) Amino acid metabolism
(B) Fatty acid synthesis
(C) Starch synthesis
(D) Cellulose synthesis

158. Lignin, a major phenolic polymer, strengthens plant tissues and also acts as a defense mechanism by:
(A) Being toxic to herbivores.
(B) Making the tissue physically tough and indigestible.
(C) Attracting beneficial insects.
(D) Storing large amounts of water.

159. Guttation, the exudation of water droplets from the leaf margins, is a result of:
(A) High transpiration rates
(B) Low root pressure
(C) High root pressure and low transpiration
(D) Stomatal closure during the day

160. Consider the following statements about phloem transport.
I. Transport in the phloem is bidirectional, from source to sink.
II. Source and sink relationships can change during the life of a plant.
III. The driving force for phloem transport is a pressure gradient.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) III only
(C) II and III only
(D) All I, II, and III

161. An essential mineral nutrient is defined as one that:
(A) Is required by the plant in very large quantities.
(B) Is required for the plant to complete its life cycle.
(C) Can be synthesized by the plant itself.
(D) Is only involved in defense responses.

162. The process where light energy is used to split water molecules, releasing electrons, protons, and oxygen, is called:
(A) Photolysis
(B) Photosynthesis
(C) Photophosphorylation
(D) Photorespiration

163. Which statement about CAM plants is incorrect?
(A) They are typically adapted to arid conditions.
(B) They open their stomata during the day to maximize CO_2 uptake.
(C) They store CO_2 as malic acid in the vacuole during the night.
(D) They exhibit temporal separation of initial CO_2 fixation and the Calvin cycle.

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164. The primary function of carotenoids as accessory pigments in photosynthesis is to:
(A) Absorb light in the green range of the spectrum.
(B) Broaden the spectrum of light absorbed and protect chlorophyll from photodamage.
(C) Serve as the primary reaction center pigment.
(D) Fix carbon dioxide in the stroma.

165. The alternative oxidase (AOX) pathway in plant mitochondria bypasses some proton-pumping sites. As a result, when electrons flow through the AOX pathway:
(A) More ATP is produced per oxygen molecule reduced.
(B) Less ATP is produced per oxygen molecule reduced.
(C) The same amount of ATP is produced.
(D) No oxygen is consumed.

166. Glycolysis is a sequence of ten enzyme-catalyzed reactions. The net result of glycolysis from one molecule of glucose is:
(A) 2 Pyruvate, 2 ATP, 2 NADH
(B) 1 Pyruvate, 4 ATP, 2 NADH
(C) 2 Acetyl-CoA, 2 ATP, 2 FADH2
(D) 2 Lactate, 2 ATP, 0 NADH

167. The process of converting atmospheric nitrogen (N2) to ammonia (NH3) is called nitrogen fixation. In biological systems, this is catalyzed by the enzyme:
(A) Nitrate reductase
(B) Nitrogenase
(C) Nitrite reductase
(D) Glutamate dehydrogenase

(D) Statement I is false, but Statement II is true.

230. Apoplastic transport of water and solutes through the root cortex is halted at the endodermis by the:
(A) Plasmodesmata
(B) Pericycle
(C) Casparian strip
(D) Root cap

231. In the first step of the Calvin cycle, CO_2 is 'fixed' by being attached to which molecule?
(A) Ribulose-1,5-bisphosphate (RuBP)
(B) Phosphoenolpyruvate (PEP)
(C) 3-Phosphoglycerate (3-PGA)
(D) Glucose

232. Which of the following is an incorrect statement about photorespiration?
(A) It occurs when RuBisCO binds O_2 instead of CO_2.
(B) It results in a net loss of previously fixed carbon.
(C) It is a highly efficient energy-producing pathway.
(D) It involves three organelles: chloroplast, peroxisome, and mitochondrion.

233. In the mitochondrial electron transport chain, which complex does NOT pump protons across the inner mitochondrial membrane?
(A) Complex I (NADH Dehydrogenase)
(B) Complex II (Succinate Dehydrogenase)
(C) Complex III (Cytochrome bc1)
(D) Complex IV (Cytochrome c Oxidase)

234. The "climacteric rise" in respiration is a characteristic feature observed during the ripening of many fruits and is triggered by the hormone:
(A) Auxin
(B) Gibberellin
(C) Cytokinin
(D) Ethylene

235. Arrange the following components of the phytochrome signaling pathway in order, starting from the light signal.
I. Change in gene expression
II. Conversion of Pr to Pfr
III. Pfr moves to the nucleus and interacts with transcription factors
IV. Absorption of red light
(A) IV, II, III, I
(B) II, IV, I, III
(C) IV, III, II, I
(D) I, III, II, IV

236. The entrainment of the circadian clock by light-dark cycles ensures that the internal rhythm of the plant is synchronized with the:
(A) Environmental 24-hour day
(B) Plant's developmental stage
(C) Availability of water
(D) Seasonal changes in temperature

237. A plant's first line of defense against pathogens is often its physical barriers. Which of the following is an example of such a barrier?
(A) The production of phytoalexins
(B) The hypersensitive response
(C) The waxy cuticle on the epidermis
(D) Systemic acquired resistance

238. An apoenzyme is defined as:
(A) An enzyme that is active without a cofactor.
(B) The protein portion of an enzyme, which is inactive without its cofactor.
(C) A non-protein organic molecule that binds to an enzyme.
(D) A fully active enzyme including all its cofactors (holoenzyme).

239. The alpha-helix and beta-sheet are examples of a protein's:
(A) Primary structure
(B) Secondary structure
(C) Tertiary structure
(D) Quaternary structure

240. The main biosynthetic precursor for phenolic compounds in plants is the aromatic amino acid:
(A) Methionine
(B) Lysine
(C) Phenylalanine
(D) Proline

241. The driving force for the translocation of photoassimilates in the phloem, according to the pressure-flow hypothesis, is a:
(A) Turgor pressure gradient between source and sink.

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(D) Pericycle

199. Given below are two statements:
Statement I: Phloem unloading at a sink can be symplastic, where sugars move from cell to cell via plasmodesmata.
Statement II: Apoplastic unloading involves the movement of sugars into the cell wall space before being taken up by sink cells.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

200. Iron (Fe) is an essential micronutrient in plants, primarily required for:
(A) The synthesis of chlorophyll and as a component of cytochromes in electron transport chains.
(B) Maintaining turgor pressure and regulating stomatal opening.
(C) The structure of the cell wall.
(D) The synthesis of DNA and RNA.

201. The overall equation for photosynthesis is $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. The oxygen ($O_2$) released comes from which reactant?
(A) Carbon dioxide (CO_2)
(B) Water (H_2O)
(C) Both CO_2 and H_2O equally
(D) Glucose ($C_6H_{12}O_6$) breakdown

202. The enzyme PEP carboxylase, which is active in C4 and CAM plants, has a high affinity for _____ and is not inhibited by _____.
(A) O_2; CO_2
(B) HCO_3^-; O_2
(C) RuBP; O_2
(D) CO_2; HCO_3^-

203. In the absence of oxygen, some plant cells can undergo fermentation to regenerate _____, allowing glycolysis to continue.
(A) NAD+
(B) NADH
(C) ATP
(D) Pyruvate

204. Which of the following processes is NOT part of photorespiration?
(A) Oxygenation of RuBP by RuBisCO in the chloroplast.
(B) Conversion of glycolate to glyoxylate in the peroxisome.
(C) Release of CO_2 from glycine in the mitochondrion.
(D) Carboxylation of PEP in the cytoplasm.

205. The biosynthesis of gibberellins, a class of tetracyclic diterpenoid acids, originates from which metabolic pathway?
(A) Shikimic acid pathway
(B) Mevalonic acid/terpenoid pathway
(C) Glycolysis
(D) Fatty acid synthesis

206. A plant breeder wants to delay the senescence of cut flowers. Spraying them with a solution containing which hormone would be most effective?
(A) Abscisic acid
(B) Ethylene
(C) Cytokinin
(D) Jasmonic acid

207. A critical component of the biological clock mechanism is a negative feedback loop. This typically involves:
(A) A photoreceptor continuously activating a gene.
(B) A protein product of a 'clock gene' inhibiting its own transcription.
(C) The accumulation of sugar from photosynthesis driving the clock.
(D) An external light signal directly stopping the clock.

208. The perception of blue light by phototropins leads to a signaling cascade that ultimately results in:
(A) The equal distribution of auxin across the stem.
(B) The lateral redistribution of auxin to the shaded side of the stem.
(C) The degradation of all auxin in the stem tip.
(D) The conversion of phytochrome from Pr to Pfr.

209. A major mechanism of plant tolerance to freezing temperatures involves:
(A) Increasing the water content of cells to prevent ice crystal formation.

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(D) Photosynthetic

253. Which of the following statements about water potential is incorrect?
(A) Pure water at standard temperature and pressure has a water potential of zero.
(B) The addition of solutes to water lowers its water potential (makes it more negative).
(C) Water moves from a region of lower water potential to a region of higher water potential.
(D) Pressure potential in a turgid plant cell is positive.

254. Which of the following is NOT a characteristic of active transport across a membrane?
(A) It requires metabolic energy (ATP).
(B) It can move solutes against a concentration gradient.
(C) It is mediated by specific carrier proteins.
(D) It is a passive process that does not require energy.

255. In the light-dependent reactions of photosynthesis, what is the role of the cytochrome b6f complex?
(A) To split water and release oxygen.
(B) To transfer electrons from Photosystem II to Photosystem I and pump protons.
(C) To reduce NADP+ to NADPH.
(D) To fix CO_2 onto RuBP.

256. The main advantage of the C4 photosynthetic pathway over the C3 pathway is that it:
(A) Allows the plant to fix CO_2 in the dark.
(B) Reduces photorespiration by concentrating CO_2 around RuBisCO.
(C) Does not require light energy.
(D) Is more efficient at low temperatures.

257. The net energy yield from the complete aerobic respiration of one molecule of glucose is approximately:
(A) 2 ATP
(B) 8 ATP
(C) 30-32 ATP
(D) 100 ATP

258. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

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Assertion (A): Cytokinins are known to delay leaf senescence.
Reason (R): Cytokinins promote the mobilization of nutrients into the leaf and maintain protein and chlorophyll synthesis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

259. A plant physiologist discovers that a certain plant flowers only when the night is less than 9 hours long. This plant is a:
(A) Short-day plant
(B) Long-day plant
(C) Day-neutral plant
(D) CAM plant

260. The hypersensitive response (HR) is a plant defense mechanism against pathogens that involves:
(A) Slow, systemic death of the entire plant.
(B) Rapid, programmed cell death localized around the infection site.
(C) Production of sweet nectar to distract the pathogen.
(D) Increased rate of photosynthesis to outgrow the infection.

261. Consider the following statements about enzymes.
I. Enzymes are biological catalysts that increase the rate of a reaction.
II. Enzymes are consumed during the reaction they catalyze.
III. The activity of an enzyme is independent of temperature and pH.
Which of the above statement(s) is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) All I, II, and III

262. The primary structure of a protein is its:
(A) Three-dimensional shape.
(B) Arrangement of alpha-helices and beta-sheets.
(C) Linear sequence of amino acids.
(D) Assembly of multiple polypeptide subunits.

288. Oxidative phosphorylation is the process where ATP is formed as a result of the transfer of electrons from:
(A) Glucose to pyruvate
(B) Pyruvate to acetyl-CoA
(C) NADH or FADH2 to O_2
(D) ADP to ATP directly

289. The biosynthesis of auxin (IAA) is derived from the amino acid _____, while the biosynthesis of ethylene is derived from the amino acid _____.
(A) Tryptophan; Methionine
(B) Methionine; Tryptophan
(C) Phenylalanine; Leucine
(D) Tyrosine; Glycine

290. Match List I with List II concerning photoreceptors and their functions.
List I: (Photoreceptor)
P. Phytochrome A
Q. Phototropin 1
R. Cryptochrome 1
S. Phytochrome B
List II: (Primary Function)
1. Mediates red-light induced seed germination
2. Mediates phototropism in response to blue light
3. Mediates responses to far-red light (e.g., shade avoidance)
4. Mediates blue-light inhibition of hypocotyl elongation
(A) P-3, Q-2, R-4, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-1, R-4, S-3

291. Systemic Acquired Resistance (SAR) provides long-lasting, broad-spectrum resistance in plants. Which molecule is a critical signaling agent for establishing SAR?
(A) Salicylic acid
(B) Auxin
(C) Abscisic acid
(D) Jasmonic acid

292. A holoenzyme is composed of:
(A) An apoenzyme alone.
(B) A coenzyme alone.
(C) An apoenzyme plus its cofactor/coenzyme.
(D) Only the protein part of an enzyme.

293. Which of the following biomolecules are characteristically amphipathic?
(A) Phospholipids
(B) Starch
(C) Triacylglycerols
(D) Glucose

294. The biosynthesis of terpenes, phenols, and nitrogenous compounds are all pathways that produce:
(A) Secondary metabolites
(B) Primary metabolites
(C) Energy storage molecules
(D) Photosynthetic pigments

295. Which of the following factors would cause stomata to close?
(A) High internal CO_2 concentration
(B) Blue light
(C) High humidity
(D) Low levels of Abscisic Acid (ABA)

296. The initial carboxylation reaction in CAM plants occurs:
(A) During the night
(B) During the day
(C) In the bundle sheath cells
(D) Only in the presence of far-red light

297. Given below are two statements:
Statement I: Glycolysis can occur under both aerobic and anaerobic conditions.
Statement II: The citric acid cycle and oxidative phosphorylation are strictly aerobic processes.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

298. Bolting, the rapid elongation of the floral stalk, in plants like cabbage can be induced by applying which hormone?
(A) Ethylene
(B) Abscisic acid
(C) Cytokinin
(D) Gibberellin

299. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Phytochrome allows plants to

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cell wall.
(D) Having a primary role in photosynthesis.

276. The symplastic pathway of transport involves movement from cell to cell through:
(A) The intercellular spaces.
(B) The cell walls.
(C) Plasmodesmata.
(D) The xylem vessels.

277. The pressure potential (Ψp) in a plasmolysed plant cell is typically:
(A) Zero or slightly negative
(B) Positive
(C) Equal to the solute potential
(D) Very high

278. In C4 plants, the enzyme RuBisCO is found in high concentrations in the:
(A) Mesophyll cells
(B) Epidermal cells
(C) Guard cells
(D) Bundle sheath cells

279. Which process occurs in the mitochondrial matrix?
(A) Glycolysis
(B) The Calvin cycle
(C) The Citric Acid Cycle
(D) Light-dependent reactions of photosynthesis

280. The biological clock is said to be "entrained" when:
(A) It is reset each day by an environmental cue, such as light.
(B) It runs freely without any external cues.
(C) It stops functioning due to a mutation.
(D) Its period changes with temperature.

281. The accumulation of compatible solutes, such as proline and glycine betaine, is a plant response to:
(A) Pathogen attack
(B) Abiotic stress like drought or salinity
(C) High light intensity
(D) Herbivore feeding

282. The 'lock and key' hypothesis of enzyme function, proposed by Emil Fischer, suggests that:
(A) The enzyme changes shape upon substrate binding.
(B) The active site has a rigid shape that is complementary to the substrate.
(C) All enzymes have the same shape.
(D) The substrate is much larger than the enzyme.

283. The linkage that joins two monosaccharides to form a Wood-disaccharide is a(n):
(A) Peptide bond
(B) Glycosidic bond
(C) Phosphodiester bond
(D) Ester linkage

284. Lignin, a complex phenolic polymer, is primarily associated with which plant tissue for providing strength and rigidity?
(A) Phloem
(B) Parenchyma
(C) Xylem
(D) Epidermis

285. Translocation of solutes from the soil to the xylem requires ions to cross at least one membrane. This selective uptake occurs primarily at the:
(A) Root hair surface
(B) Cortex cells
(C) Endodermis
(D) Xylem parenchyma

286. Which of the following is NOT a product of the light-dependent reactions of photosynthesis?
(A) ATP
(B) NADPH
(C) O_2
(D) CO_2

287. Which of the following is a key difference between C4 and CAM photosynthesis?
(A) C4 plants use PEP carboxylase, while CAM plants use RuBisCO.
(B) C4 plants have spatial separation of initial CO_2 fixation and the Calvin cycle; CAM plants have temporal separation.
(C) C4 plants are adapted to arid conditions, while CAM plants are adapted to wet tropical conditions.
(D) C4 plants fix CO_2 into a 3-carbon acid, while CAM plants fix it into a 4-carbon acid.

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38. (B) Ethylene
The triple response is a specialized growth habit observed in seedlings when they encounter mechanical obstacles in the soil. This response is mediated by ethylene and consists of three distinct changes: the inhibition of stem elongation, the thickening of the stem through radial swelling, and the development of an exaggerated apical hook. These modifications allow the seedling to emerge safely.

39. (A) Both Statement I and Statement II are true.
Apical dominance is a phenomenon where the terminal bud inhibits the growth of lateral buds, a process primarily controlled by auxins produced at the shoot tip. Conversely, cytokinins, which are often produced in the roots and transported upward, promote the development of lateral buds. The balance between these two hormones determines the overall branching pattern and architecture of the plant.

40. (A) Promoting stem elongation and seed germination
Gibberellins are a class of plant hormones that play a vital role in promoting stem elongation by stimulating both cell division and cell expansion. They are also essential for breaking seed dormancy and initiating the germination process by inducing the synthesis of hydrolytic enzymes. These effects are fundamentally opposite to the inhibitory actions of hormones like abscisic acid.

41. (D) All I, II, and III
Abscisic acid is recognized as a stress hormone because it mediates responses to environmental challenges like drought. Auxins exhibit polar transport, moving from the shoot tip toward the base. Cytokinins are primarily synthesized in root tips before being transported to other parts of the plant. These hormones collectively regulate growth, development, and stress responses throughout the entire plant life cycle.

42. (A) Nitrate reductase
The assimilation of nitrogen begins with the reduction of nitrate to nitrite, a critical step catalyzed by the enzyme nitrate reductase. This enzyme is located in the cytosol and requires a molybdenum cofactor and reducing power, typically from NADH. Once nitrite is formed, it is transported into plastids or chloroplasts, where it is further reduced to ammonium for amino acid synthesis.

43. (D) It is an entirely unregulated process of decay.
Senescence is a sophisticated and genetically programmed degenerative process, not a random or unregulated decay. It involves the orderly breakdown and recycling of nutrients, which is essential for the plant's overall survival and reproductive success. While hormones like ethylene and abscisic acid accelerate this process, cytokinins can delay it, demonstrating that senescence is under tight physiological and genetic control.

44. (B) Adenine
Cytokinins are a group of plant hormones that promote cell division and delay leaf senescence. Their chemical structure is characterized by a substituted adenine ring. The biosynthesis of these hormones involves the modification of adenine-containing compounds, such as adenosine monophosphate, by adding an isoprenoid or aromatic side chain. This fundamental structural relationship is key to their biological activity in plants.

45. (C) Receptor binding cascades.
Plant hormones typically exert their effects by binding to specific receptor proteins located on the cell surface or within the cytoplasm. This binding initiates a signal transduction cascade, which often involves protein phosphorylation or the degradation of repressor proteins. These cascades ultimately lead to changes in gene expression or cellular activity, allowing the plant to respond to various internal and external cues.

46. (D) Phytochrome
Phytochromes are specialized photoreceptors that exist in two interconvertible forms, allowing plants to sense red and far-red light. This sensory system is fundamental for regulating many aspects of the plant life cycle, including seed germination, seedling development, and the timing of flowering. By monitoring the ratio of red to far-red light, phytochromes enable plants to adapt to their light environment.

47. (A) Phototropin
Phototropism is the growth response of plants toward or away from a light source, primarily

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sense the quality of light, such as in shade versus full sun.
Reason (R): Shaded light is enriched in far-red light, which converts the active Pfr form to the inactive Pr form, triggering shade avoidance responses.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

300. The primary difference between a vitamin and a mineral nutrient is that:
(A) Vitamins are organic molecules, while minerals are inorganic elements.
(B) Vitamins are required in large amounts, while minerals are not.
(C) Minerals are organic, while vitamins are inorganic.
(D) Plants can synthesize all necessary minerals but not vitamins.

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specialized pigments called xanthophylls are converted into forms that can safely dissipate excess energy as heat. This process prevents the formation of reactive oxygen species and protects the photosynthetic apparatus from irreversible photo-oxidative damage during environmental stress.

20. (A) Both A and R are true and R is the correct explanation of A.
C4 plants exhibit higher photosynthetic efficiency in hot, dry climates compared to C3 plants. This advantage stems from their ability to concentrate carbon dioxide within the bundle sheath cells where RuBisCO is located. By maintaining high carbon dioxide levels, these plants suppress the oxygenase activity of RuBisCO, thereby minimizing photorespiration and maximizing the rate of carbon assimilation.

21. (C) Vacuoles
In CAM plants, carbon dioxide is initially fixed at night by the enzyme PEP carboxylase to form oxaloacetate, which is then converted into malic acid. This malic acid is actively transported and stored inside the large central vacuoles of the mesophyll cells. During the following day, the malic acid is released and decarboxylated to provide carbon dioxide for photosynthesis.

22. (B) C4 pathway - RuBisCO in mesophyll
In C4 plants, the initial fixation of carbon dioxide occurs in the mesophyll cells using the enzyme PEP carboxylase. However, the enzyme RuBisCO is specifically localized within the bundle sheath cells, where the Calvin cycle takes place. Stating that RuBisCO is the primary fixing enzyme in the mesophyll of C4 plants is incorrect according to their specialized leaf anatomy.

23. (D) Cytosol
Glycolysis is the initial stage of cellular respiration where a single molecule of glucose is broken down into two molecules of pyruvate. This sequence of ten enzyme-catalyzed reactions occurs entirely within the cytosol of the plant cell. Because it does not require oxygen or specialized organelles, glycolysis is a universal metabolic pathway found in nearly all living organisms.

24. (A) I and II only
The citric acid cycle takes place within the mitochondrial matrix and begins when acetyl-CoA reacts with oxaloacetate. While the cycle itself does not use oxygen directly, it is considered an aerobic process because it is functionally linked to the electron transport chain, which requires oxygen. Therefore, describing the citric acid cycle as an anaerobic process is factually incorrect.

25. (C) Alternative oxidase pathways.
Plant mitochondria possess a unique feature called the alternative oxidase pathway, which is generally absent in animal systems. This pathway allows electrons to bypass the traditional cytochrome-mediated steps of the electron transport chain. By doing so, it provides plants with a mechanism to manage metabolic flexibility, regulate redox balance, and produce heat, especially under various environmental stress conditions.

26. (A) Chloroplast, Peroxisome, and Mitochondrion
Photorespiration is a complex metabolic pathway that involves the coordinated activity of three distinct organelles. It begins in the chloroplast when RuBisCO reacts with oxygen. The resulting intermediates are then processed in the peroxisome and subsequently in the mitochondrion, where carbon dioxide is released. Finally, the pathway returns to the chloroplast to recover some of the lost carbon atoms.

27. (D) 2 ATP
Glycolysis is the metabolic pathway that breaks down one molecule of glucose into two molecules of pyruvate. Although four ATP molecules are produced during the energy-yielding phase, two ATP molecules are consumed in the initial energy-investment phase. Therefore, the process results in a net gain of exactly two ATP molecules for the cell to use as energy.

28. (B) Photorespiration
RuBisCO is a bifunctional enzyme that can react with either carbon dioxide or oxygen. When the concentration of oxygen is high or temperatures are elevated, RuBisCO exhibits oxygenase activity. This reaction initiates photorespiration, a process that leads to the production of phosphoglycolate. This pathway eventually consumes energy and

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sink tissues, where the solutes are unloaded and the pressure is lower.

10. (A) Plasmolysis
When a plant cell is placed in a hypertonic solution, the external environment has a higher solute concentration and a lower water potential than the cell interior. Consequently, water exits the cell through osmosis. This loss of water causes the protoplast to shrink and eventually pull away from the rigid cell wall, a condition specifically known as plasmolysis.

11. (A) I and II only
Macronutrients are essential elements required by plants in relatively large amounts, generally exceeding ten millimoles per kilogram of dry matter. Micronutrients are equally essential but are needed only in trace quantities. While nitrogen and potassium are macronutrients, boron and zinc are classified as micronutrients because they are required in much smaller concentrations for healthy plant development.

12. (B) Fixing carbon dioxide
The light-harvesting complex consists of pigments and proteins that capture light energy and transfer it to the reaction center. It also serves a protective role by dissipating excess energy to prevent damage. However, the chemical fixation of carbon dioxide is a separate process that occurs during the Calvin cycle in the stroma, independent of the light-harvesting complex.

13. (C) Concentrate CO_2 to reduce photorespiration.
The C4 pathway is an adaptation that helps plants minimize photorespiration, particularly in hot and dry environments. By physically separating initial carbon fixation from the Calvin cycle, C4 plants can maintain a high concentration of carbon dioxide around the enzyme RuBisCO. This ensures that RuBisCO primarily reacts with carbon dioxide rather than oxygen, increasing overall photosynthetic efficiency.

14. (D) Stroma to the thylakoid lumen.
During the light-dependent reactions of photosynthesis, electrons move through a series of carriers in the thylakoid membrane. This electron flow provides the energy necessary to actively pump protons from the stroma into the thylakoid lumen. The resulting proton gradient across the membrane is then used by ATP synthase to produce ATP, which is essential for the Calvin cycle.

15. (A) Both Statement I and Statement II are true.
Crassulacean Acid Metabolism is a specialized photosynthetic pathway where plants fix carbon dioxide at night when temperatures are cooler. This carbon is stored as malic acid and then released for the Calvin cycle during the day. This temporal separation allows the plants to keep their stomata closed during the hottest hours, significantly reducing water loss in arid environments.

16. (B) NADP+
In the non-cyclic electron transport chain, also known as the Z-scheme, electrons are initially extracted from water molecules and then passed through various protein complexes. After traveling through photosystem II and photosystem I, these high-energy electrons are ultimately transferred to NADP+. The enzyme ferredoxin-NADP+ reductase facilitates this transfer, resulting in the production of NADPH for use in carbon fixation.

17. (B) Ribulose-1,5-bisphosphate carboxylase
The C3 pathway, or the Calvin cycle, relies on the enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase, commonly known as RuBisCO. This enzyme catalyzes the first step of carbon fixation by attaching carbon dioxide to a five-carbon sugar molecule. This reaction produces two molecules of 3-phosphoglycerate, which serves as the fundamental building block for the synthesis of carbohydrates in most plant species.

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18. (A) III, I, IV, II
Non-cyclic photophosphorylation begins with the photolysis of water, which provides electrons to the system. These electrons move to the reaction center of photosystem II, causing the excitation of P680. The electrons then travel through an electron transport chain to photosystem I, leading to the excitation of P700. Finally, these electrons are used to reduce NADP+ into NADPH.

19. (C) Photo-protective mechanism.
The xanthophyll cycle is a vital photo-protective mechanism that helps plants manage excessive light energy. When light intensity is too high,

ANSWERS

1. (B) Transpiration
Transpiration is the biological process that involves the loss of water vapor from the aerial parts of a plant, primarily through stomata. This phenomenon effectively connects the soil, plant body, and atmosphere. It creates a suction force that pulls water and minerals from the roots upwards, facilitating long-distance transport while simultaneously cooling the plant surfaces.

2. (C) Statement I is true, but Statement II is false.
Water potential represents the free energy of water per unit volume and dictates the direction of spontaneous water movement. Water naturally moves from a region with higher water potential to one with lower water potential. While the first statement correctly defines the concept, the second statement incorrectly describes the direction of the gradient governing the flow.

3. (C) Solute potential
In a plasmolysed plant cell, the protoplast shrinks away from the cell wall because water has left the cell. At this stage, the pressure potential typically reaches zero or becomes negative. Consequently, the water potential is predominantly determined by the solute potential, which represents the effect of dissolved substances on the free energy of water.

4. (D) Active transport
Mineral ions in the soil are often present in lower concentrations than inside the root cells. Additionally, these ions carry charges and cannot cross cell membranes through simple diffusion. Plants utilize specialized proteins and metabolic energy in the form of ATP to move these minerals into the roots against their concentration gradient, a process termed active transport.

5. (C) Water moves out of the phloem into the xylem after loading.
Phloem loading involves the active transport of sugars into sieve-tube elements, which significantly lowers their solute potential. This change creates a water potential gradient that causes water to move from the xylem into the phloem by osmosis. Therefore, the statement claiming water moves out of the phloem into the xylem immediately after loading is biologically incorrect.

6. (A) P-4, Q-1, R-3, S-2
The apoplast pathway involves water movement through cell walls and intercellular spaces. The symplast pathway utilizes plasmodesmata for cell-to-cell transport. The transmembrane pathway describes water moving directly across cell membranes. Xylem transport is characterized by the bulk flow of water and minerals driven by pressure gradients. These mechanisms collectively facilitate the movement of fluids within plants.

7. (D) An increase in the turgor pressure of the guard cells.
Stomatal opening is triggered by the accumulation of solutes, such as potassium ions, within the guard cells. This solute buildup lowers the water potential, causing water to enter the cells via osmosis. The resulting increase in turgor pressure causes the guard cells to swell and bow outward, which creates the opening known as the stomatal pore.

8. (A) Both A and R are true and R is the correct explanation of A.
Water transport in the xylem is considered a passive process because it does not require the direct expenditure of metabolic energy by the plant. The cohesion-tension theory explains that the evaporation of water from leaves creates a negative pressure, or tension. This pull is transmitted through a continuous water column, facilitated by the cohesive properties of water.

9. (C) The translocation of photoassimilates in phloem.
The pressure-flow hypothesis is the most widely accepted mechanism explaining how sugars move through the phloem. It proposes that a high concentration of organic solutes at the source creates a turgor pressure gradient. This pressure drives the bulk flow of the phloem sap toward the

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releases fixed carbon, making it less efficient than the standard Calvin cycle.

29. (A) Both Statement I and Statement II are true.
In the plant mitochondrial electron transport chain, oxygen serves as the ultimate electron acceptor, combining with protons to form water. This flow of electrons powers the pumping of protons across the inner membrane, creating a gradient. ATP synthesis is then driven by the movement of these protons back through ATP synthase, a process known as chemiosmotic coupling.

30. (D) Preventing system over-reduction.
The alternative oxidase pathway in plant mitochondria serves as a metabolic relief valve. When the traditional electron transport chain becomes saturated or inhibited, the alternative oxidase allows electrons to flow directly to oxygen. This prevents the over-reduction of electron carriers and the subsequent formation of harmful reactive oxygen species, thereby maintaining cellular redox homeostasis under fluctuating or stressful conditions.

31. (A) P-2, Q-4, R-1, S-3
Glycolysis occurs in the cytosol, while the citric acid cycle takes place in the mitochondrial matrix. Oxidative phosphorylation is located on the inner mitochondrial membrane, utilizing the electron transport chain to produce ATP. Photorespiration is a distinct, often wasteful process that involves the release of carbon dioxide. Each process is specialized to occur within specific compartments of the plant cell.

32. (B) Pyruvate
The citric acid cycle is a central metabolic pathway that oxidizes acetyl-CoA to produce energy-rich molecules. The primary products include carbon dioxide, NADH, FADH2, and ATP or GTP. Pyruvate is not a product of this cycle; instead, it is the precursor that is converted into acetyl-CoA before entering the mitochondria. This distinction is crucial for understanding cellular respiration.

33. (B) Glutamine synthetase
The assimilation of ammonium into organic compounds primarily occurs through the GS-GOGAT pathway. Glutamine synthetase catalyzes the initial step by attaching ammonium to a molecule of glutamate to form glutamine. This process requires energy in the form of ATP. Subsequently, glutamate synthase transfers the amide group to another molecule to produce two molecules of glutamate, continuing the cycle.

34. (A) Indole-3-acetic acid (Auxin)
Auxins, specifically indole-3-acetic acid, are essential plant hormones that regulate growth and development. Their biosynthesis primarily involves the amino acid tryptophan as a precursor. Tryptophan undergoes several enzymatic transformations, including decarboxylation and deamination, to eventually form the active auxin molecule. This hormone is crucial for processes such as cell elongation, apical dominance, and various tropic responses in plants.

35. (C) An increase in cell division and growth.
Senescence is a highly regulated, genetically programmed process that marks the final stage of development in plant organs. It is characterized by the systematic breakdown of cellular components like chlorophyll and proteins, alongside a decline in photosynthesis. During this phase, nutrients are mobilized and recycled to younger tissues. Therefore, an increase in cell division contradicts the degenerative nature of senescence.

36. (C) A is true but R is false.
For plants to use nitrate for the synthesis of organic molecules, it must first be converted into ammonium. This reduction process occurs in two steps catalyzed by nitrate reductase and nitrite reductase. While plants can absorb nitrate, their enzymes cannot directly incorporate it into amino acids without first reducing it to the more reactive ammonium form in the cytoplasm and plastids.

37. (C) Ethylene
Ethylene is a gaseous plant hormone that plays a central role in various physiological processes, most notably fruit ripening. It acts as a signaling molecule that triggers the expression of genes involved in softening, color change, and sugar accumulation. Because it is a gas, ethylene can easily accumulate in storage areas, causing fruits to ripen prematurely and eventually spoil.

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263. The biosynthesis of tannins, which are complex phenolic compounds, follows the:
(A) Mevalonic acid pathway
(B) Shikic acid pathway
(C) Glyoxylate cycle
(D) Beta-oxidation pathway

264. The movement of water through the continuous network of cell walls and intercellular air spaces in the root cortex is called the:
(A) Symplast pathway
(B) Apoplast pathway
(C) Transmembrane pathway
(D) Vacuolar pathway

265. Given below are two statements:
Statement I: Phloem loading can be symplastic, where sucrose moves from mesophyll to sieve elements via plasmodesmata.
Statement II: Symplastic loading does not require energy in the form of ATP.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

266. Which pair of mineral nutrients are both considered macronutrients?
(A) Potassium and Calcium
(B) Nitrogen and Iron
(C) Phosphorus and Zinc
(D) Sulfur and Boron

267. In non-cyclic photophosphorylation, electrons flow from _____ to _____.
(A) H_2O; NADP+
(B) NADP+; H_2O
(C) Photosystem I; Photosystem II
(D) Cytochrome b6f; H_2O

268. Which molecule is both the initial reactant and the final product to be regenerated in the Calvin cycle?
(A) 3-PGA
(B) G3P
(C) RuBP
(D) Glucose

269. The main function of the Krebs cycle (citric acid cycle) is to:
(A) Produce a large amount of ATP directly.
(B) Generate reducing power (NADH and FADH2) from the oxidation of acetyl-CoA.
(C) Consume oxygen and produce water.
(D) Convert pyruvate to lactate.

270. Abscission, the shedding of leaves, flowers, and fruits, is promoted by a high ratio of _____ to _____.
(A) ethylene/ABA; auxin
(B) auxin; cytokinin
(C) gibberellin; auxin
(D) cytokinin; gibberellin

271. Vernalization is the process by which flowering is promoted by exposure to:
(A) Prolonged cold.
(B) A long dark period.
(C) A flash of far-red light.
(D) High humidity.

272. A plant is subjected to high-intensity light that exceeds its photosynthetic capacity. Which of the following is a likely photoprotective response?
(A) The dissipation of excess energy as heat via the xanthophyll cycle.
(B) An increase in the synthesis of chlorophyll.
(C) The permanent disassembly of photosystem II.
(D) A rapid increase in the rate of photorespiration only.

273. Enzyme kinetics studies the:
(A) Structure of the enzyme's active site.
(B) Rate of enzyme-catalyzed reactions and how it changes in response to experimental parameters.
(C) Evolutionary origin of enzymes.
(D) Genetic code for the enzyme.

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274. Which of the following is NOT a polymer?
(A) Starch
(B) DNA
(C) Protein
(D) Glucose

275. Alkaloids, such as caffeine and nicotine, are secondary metabolites that are characterized by:
(A) Being composed of isoprene units.
(B) Containing at least one nitrogen atom, often in a heterocyclic ring.
(C) Being major structural components of the

mediated by blue-light photoreceptors called phototropins. When a plant perceives a light gradient, phototropins trigger the lateral redistribution of auxin toward the shaded side of the stem. This asymmetric auxin distribution leads to differential cell elongation, causing the plant to bend specifically toward the light.

48. (A) II, I, III, IV
The process begins when the phytochrome chromophore absorbs light energy, which triggers a conformational change in the protein from the inactive Pr form to the active Pfr form. This active Pfr form is then translocated from the cytoplasm into the nucleus. Once inside the nucleus, it interacts with various transcription factors to regulate the expression of specific genes, initiating physiological responses.

49. (B) An internal, endogenous oscillator that controls circadian rhythms.
The biological clock is an internal timing mechanism that allows plants to coordinate their physiological processes with the 24-hour day-night cycle. This endogenous oscillator generates circadian rhythms, which persist even in the absence of external light or temperature cues. It enables plants to anticipate environmental changes and optimize activities like photosynthesis, leaf movement, and the opening of stomata for maximum efficiency.

50. (A) Both Statement I and Statement II are true.
Photoperiodism is the physiological reaction of plants to the relative lengths of daylight and darkness. Long-day plants are specific types that require a light period exceeding a critical threshold to initiate flowering. This mechanism ensures that plants flower during the appropriate season when pollinators are active and environmental conditions are favorable for seed development and successful reproduction.

51. (B) P-2, Q-1, R-4, S-3
Phytochromes are specialized pigments that primarily absorb red and far-red light to regulate plant development. Cryptochromes are flavoproteins that sense blue and ultraviolet-A light for circadian clock regulation. Phototropins are also blue-light receptors but specifically mediate phototropism and stomatal opening. Chlorophyll is the main photosynthetic pigment, absorbing blue and red light to drive the conversion of energy during photosynthesis.

52. (D) Induction of flowering by exposure to prolonged cold temperatures.
Vernalization is a physiological process where a plant's ability to flower is induced or accelerated by a prolonged period of exposure to low temperatures. This mechanism is common in many winter annuals and biennials, ensuring that they do not flower during the winter but rather wait until the following spring when the climate is warmer and more suitable for growth.

53. (A) Both A and R are true and R is the correct explanation of A.
Phytochrome is a light-sensitive protein that exists in two interconvertible forms. The Pr form is considered inactive and absorbs red light, which converts it into the biologically active Pfr form. Once in the Pfr state, the protein can initiate various physiological and developmental responses. Exposure to far-red light reverses this process, converting the active Pfr back into the inactive Pr form.

54. (B) It stops completely in the absence of an external light cue.
A fundamental characteristic of the biological clock is its endogenous and self-sustaining nature. While external cues like light and temperature help to reset or entrain the clock to the environmental 24-hour cycle, the rhythm itself will continue to persist even under constant conditions. Furthermore, the clock is temperature-compensated, meaning its period remains relatively stable despite changes in the surrounding temperature.

55. (D) Linear tetrapyrrole
The light-absorbing portion of the phytochrome molecule is a specialized pigment known as a chromophore. Specifically, this chromophore is a linear tetrapyrrole called phytochromobilin. It is covalently attached to the protein component of phytochrome and undergoes a cis-trans isomerization upon absorbing a photon. This chemical change is what triggers the structural transformation of the entire protein between its Pr and Pfr forms.

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chain. Although the cycle is aerobic because it requires the products of the electron transport chain to continue, it does not directly react with or consume oxygen molecules.

128. (B) Complex IV (cytochrome c oxidase) of the electron transport chain
Cyanide is a deadly poison because it acts as a potent inhibitor of cellular respiration. It binds specifically to the iron atom within complex IV, also known as cytochrome c oxidase, in the mitochondrial electron transport chain. This binding prevents the final transfer of electrons to oxygen, effectively stopping the production of ATP and leading to a rapid cessation of metabolic activity in the cell.

129. (A) Intermediates of photosynthesis and respiration.
To synthesize amino acids, plants require both a source of nitrogen and carbon skeletons. These carbon frameworks are provided by various intermediates produced during primary metabolic processes. Specifically, molecules from the Calvin cycle, glycolysis, and the citric acid cycle are diverted into biosynthetic pathways. This integration ensures that amino acid production is directly linked to the plant's overall energy and carbon status.

130. (B) Activates wall-loosening enzymes.
The acid growth hypothesis explains how auxin promotes rapid cell elongation. According to this theory, auxin stimulates proton pumps in the plasma membrane, which lower the pH of the cell wall. This acidification activates specialized enzymes, such as expansins, that break the cross-links between cellulose microfibrils. As the wall loosens, the cell's internal turgor pressure causes it to expand and grow.

131. (D) All I, II, and III
Plant hormones often work in coordination to regulate complex developmental processes. Ethylene is a gaseous signal that triggers fruit ripening and leaf abscission. Abscisic acid is crucial for survival, promoting seed dormancy and the closure of stomata during drought. Additionally, auxins and gibberellins often collaborate to drive stem elongation. These examples highlight the multifaceted and integrated nature of hormonal control in plants.

132. (B) Pr
Phytochrome exists in two interconvertible forms that allow it to act as a biological switch. The Pr form absorbs red light and is considered the inactive state. In plants grown in the dark, or during the long nights, phytochrome primarily accumulates in this Pr form. Upon exposure to light, it is converted into the active Pfr form, which then initiates various light-dependent developmental responses.

133. (B) The length of the uninterrupted dark period.
Photoperiodism allows plants to sense the season by measuring day length, but experimental evidence shows that the duration of the uninterrupted dark period is the critical factor. For example, interrupting a long night with a brief pulse of light can prevent a short-day plant from flowering. This demonstrates that the plant's internal timing mechanism specifically tracks the continuous absence of light.

134. (C) Shade avoidance response
Blue-light photoreceptors, including cryptochromes and phototropins, regulate essential processes such as phototropism, stomatal opening, and the inhibition of seedling stem elongation. However, the shade avoidance response is primarily mediated by phytochromes. This response is triggered by a low ratio of red to far-red light, which occurs when a plant is shaded by the leaves of other plants, signaling it to grow taller.

135. (B) Salt avoidance
Salt avoidance is a strategy used by some plants to prevent the accumulation of toxic salt levels in their tissues. This can be achieved through mechanisms such as salt exclusion at the root surface or the active secretion of excess salt through specialized salt glands on the leaves. Unlike tolerance, which involves coping with salt inside the cells, avoidance focuses on minimizing the plant's internal exposure.

136. (A) Changes in pH can alter the ionization state of amino acid residues in the active site.
The catalytic activity of an enzyme is highly dependent on the pH of its environment. This is because the amino acids within the enzyme's active site have specific ionization states that are required for substrate binding and chemical

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65. (B) Drought tolerance
Drought tolerance is the physiological ability of a plant to maintain its essential functions and survive during periods of significant water scarcity. This involves adaptations such as deep root systems, stomatal regulation, and the accumulation of osmoprotectants to prevent cellular damage. While some plants avoid drought by completing their life cycle quickly, tolerant plants have mechanisms to withstand prolonged dry conditions.

66. (A) Abscisic acid (ABA)
Abscisic acid is a critical plant hormone that serves as a primary signal for responding to water stress. When a plant experiences a water deficit, ABA levels rise in the leaves. This hormone triggers a series of events in the guard cells, leading to an efflux of ions and a subsequent loss of turgor pressure. This results in the rapid closure of stomata.

67. (B) Both A and R are true but R is not the correct explanation of A.
High soil salinity creates an osmotic challenge by lowering water potential, which restricts the ability of roots to absorb water. Beyond this osmotic effect, the excessive accumulation of specific ions like sodium can cause direct biochemical toxicity within plant cells. While both statements are factually accurate, the toxic effect of ions is a separate physiological consequence from the initial osmotic stress.

68. (D) Resistance to biotic stress (pathogens).
Phytoalexins are specialized antimicrobial compounds synthesized by plants in response to infection by pathogens such as fungi or bacteria. These secondary metabolites are part of the plant's induced defense system and work by inhibiting the growth and reproduction of the invading organism. The production of phytoalexins is a classic example of a chemical defense mechanism against biotic stress.

69. (C) Compartmentalizing excess salt in the vacuole.
Halophytes have evolved specialized mechanisms to survive in high-salinity environments. A common strategy involves the active transport and sequestration of excess sodium and chloride ions into the large central vacuoles of their cells. By compartmentalizing these potentially toxic ions, the plant can maintain a lower osmotic potential in the cytoplasm using compatible solutes, allowing for continued water uptake without cellular damage.

70. (B) Substrate
A substrate is the specific molecule upon which an enzyme acts during a biochemical reaction. It binds to the enzyme's active site, forming a temporary enzyme-substrate complex. This interaction lowers the activation energy required for the reaction to occur, leading to the conversion of the substrate into products. The enzyme itself remains unchanged after the reaction is complete and can be reused.

71. (B) P-4, Q-2, R-1, S-3
Oxidoreductases catalyze oxidation-reduction reactions, while transferases move functional groups between molecules. Hydrolases facilitate the cleavage of chemical bonds through the addition of water. Lyases are unique because they catalyze the breaking of various chemical bonds by means other than hydrolysis or oxidation, often resulting in the formation of double bonds. These categories define the diverse catalytic capabilities of enzymes.

72. (A) The substrate concentration at which the reaction velocity is half of the maximum.
The Michaelis constant, denoted as Km, is a fundamental parameter in enzyme kinetics. it represents the substrate concentration at which the reaction rate is exactly half of its maximum velocity. A low Km value indicates that the enzyme has a high affinity for its substrate, meaning it can achieve half-maximum velocity even at low concentrations, while a high Km suggests lower affinity.

73. (C) The active site
A competitive inhibitor is a molecule that closely resembles the chemical structure of an enzyme's natural substrate. Because of this similarity, it competes with the substrate for binding to the enzyme's active site. When the inhibitor occupies the active site, it prevents the substrate from binding, thereby reducing the rate of the reaction.

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56. (A) Sensing gravity
Cryptochromes are a class of blue-light photoreceptors that play essential roles in regulating plant development, including de-etiolation and the synchronization of the circadian clock. They also work alongside phototropins to mediate light-directed growth. However, the perception of gravity, or gravitropism, is a separate sensory process primarily involving specialized cells called statocytes and is not a function of the cryptochrome system.

57. (C) The night length is longer than a critical minimum.
Short-day plants are more accurately described as long-night plants because their flowering is determined by the length of the continuous dark period. They will only flower when the night length exceeds a specific critical duration. If this long period of darkness is interrupted by even a brief flash of light, the plant will perceive the night as short and fail to flower.

58. (A) Leaves
Although the transition to flowering occurs at the apical meristem, the perception of the photoperiodic stimulus actually takes place in the leaves. Once the leaves detect the appropriate day or night length, they produce a mobile signal, often referred to as florigen, which is transported through the phloem to the shoot apex. This signal then triggers the developmental change from vegetative to reproductive growth.

59. (D) They are primarily responsible for detecting red light.
Phototropins are specialized protein kinases located in the plasma membrane that are specifically sensitive to blue light. Upon absorbing blue light, they undergo autophosphorylation, which initiates a signaling pathway leading to the redistribution of auxin. This hormone movement causes differential growth and allows the plant to bend toward light. Red light, however, is sensed by phytochromes rather than phototropins.

60. (B) Resistance
Resistance refers to the inherent ability of a plant to identify and defend itself against potential pathogens. This involves the activation of various physiological and biochemical defense mechanisms, such as the production of antimicrobial compounds or the reinforcement of cell walls. Resistance helps to limit the growth and spread of the pathogen, thereby protecting the plant from significant damage or disease.

61. (D) All I, II, and III
Plants employ diverse strategies to cope with environmental stresses. High temperatures trigger the production of heat-shock proteins that protect cellular proteins from denaturation. Water stress often leads to the accumulation of compatible solutes, which help maintain osmotic balance. Similarly, salt stress causes stomatal closure to minimize water loss. These responses collectively demonstrate the complex mechanisms plants use to survive challenging conditions.

62. (D) Emitting volatiles to attract predators.
When plants are attacked by insect herbivores, they often respond by releasing specific volatile organic compounds into the atmosphere. These chemical signals act as indirect defenses by attracting natural enemies of the herbivores, such as predatory insects or parasitoids. This sophisticated interaction helps reduce the pest population and provides the plant with an effective biological means of resistance against herbivory.

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63. (A) Rapid, localized cell death at the site of infection.
The hypersensitive response is a powerful defense mechanism used by plants to stop the spread of biotrophic pathogens. It involves a rapid and highly localized programmed cell death at the initial site of infection. By sacrificing a few cells, the plant effectively isolates the pathogen and prevents it from accessing nutrients and spreading to healthy tissues, thereby containing the disease.

64. (A) Both Statement I and Statement II are true.
Plant stresses are broadly categorized into abiotic and biotic types. Abiotic stresses arise from non-living environmental factors, such as drought, salinity, and extreme temperatures, which can negatively impact plant growth. Biotic stresses, on the other hand, are caused by living organisms, including bacteria, fungi, viruses, and insects. Both types of stress require the plant to

83. (A) II, IV, III, I
The pressure-flow model begins with the active loading of sucrose into sieve tubes at the source. This accumulation causes water to enter by osmosis, which increases turgor pressure. This pressure gradient drives the bulk flow of the sap toward the sink tissues. Finally, the process concludes with the unloading of sucrose at the sink, which allows water to exit the phloem.

84. (D) Isopentenyl diphosphate (IPP)
Terpenes represent a vast and diverse class of secondary metabolites in plants, with functions ranging from defense to attracting pollinators. All terpenes are synthesized from basic five-carbon building blocks. The primary precursor for these units is isopentenyl diphosphate. Through various enzymatic pathways, these units are combined and modified to create the complex structures characteristic of monoterpenes, sesquiterpenes, and larger terpenoid molecules.

85. (C) A is true but R is false.
The mevalonic acid pathway is indeed one of the primary metabolic routes for synthesizing the five-carbon building blocks of terpenes. However, terpenes are primarily composed of carbon and hydrogen atoms, often arranged in cyclic or linear structures, and do not typically contain nitrogen. Nitrogen-containing secondary metabolites are categorized as alkaloids, which represent a distinct group of plant defense compounds.

86. (B) Shikic acid pathway
Phenolic compounds, including flavonoids, tannins, and lignins, are essential for plant defense and structural integrity. Their biosynthesis primarily originates from the shikic acid pathway, which also produces the aromatic amino acids phenylalanine, tyrosine, and tryptophan. Phenylalanine then serves as the starting point for the phenylpropanoid pathway, leading to the vast array of phenolic substances found in various plant tissues.

87. (D) Structural support and defense
Lignin is a complex phenolic polymer that is deposited in the secondary cell walls of many plants, particularly in vascular tissues. It provides essential structural support, allowing plants to grow tall and withstand mechanical stress. Furthermore, lignin acts as a formidable physical barrier against pathogens and herbivores, making plant tissues tough and difficult to digest, thus playing a dual role in plant survival.

88. (A) Morphine
Alkaloids are a diverse group of nitrogen-containing secondary metabolites often derived from amino acids. They are well-known for their potent physiological effects on humans and animals, frequently serving as defensive compounds against herbivores. Morphine is a classic example of an alkaloid, specifically an isoquinoline alkaloid. In contrast, menthol is a terpene, carotene is a tetraterpene, and lignin is a phenolic polymer.

89. (D) Statement I is false, but Statement II is true.
Primary metabolites are essential for the basic survival, growth, and reproduction of all plants. Secondary metabolites, however, are not universally required for basic metabolism but are crucial for a plant's interaction with its environment. They play vital roles in defense against pests and diseases, attracting pollinators through scents and colors, and influencing the growth of neighboring plants through allelopathic interactions.

90. (A) Amino acids
Nitrogenous secondary metabolites, such as alkaloids and cyanogenic glycosides, are synthesized using precursors from primary metabolism. The most common starting materials for these complex molecules are various amino acids, including lysine, tyrosine, and tryptophan. Through series of specialized enzymatic reactions, these amino acids are transformed into diverse defensive and signaling compounds that enhance the plant's fitness in its natural habitat.

91. (D) Negative or zero
Solute potential, also known as osmotic potential, measures the effect of dissolved solutes on the free energy of water. Pure water has a solute potential of zero. When solutes are added, they decrease the free energy, making the solute potential negative. In plant cells, which always contain some dissolved substances, the solute potential is consistently a negative value.

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110. (A) Flowers regardless of the day length.
Day-neutral plants are a group of plant species whose flowering is not regulated by the relative lengths of daylight and darkness. Unlike short-day or long-day plants, these species initiate flowering based on other internal developmental cues, such as reaching a certain age or size, rather than the seasonal changes in photoperiod. This adaptation allows them to flower across various latitudes and seasons.

111. (A) I and III only
Plants utilize multiple photoreceptors to monitor their light environment. Phytochromes, cryptochromes, and phototropins each serve distinct roles in growth and development. While phytochromes sense red and far-red light, cryptochromes are blue-light receptors involved in circadian rhythms. Phototropins also absorb blue light and are essential for mediating stomatal opening. These statements accurately reflect the diversity and function of plant light sensors.

112. (B) The biological clock
Nyctinasty refers to the rhythmic, sleep-like movements of leaves that occur in a daily cycle. This behavior is not a direct response to light or gravity but is instead controlled by the plant's internal biological clock. This endogenous oscillator ensures that leaf movements persist even in constant environmental conditions, allowing the plant to optimize light capture and minimize water loss according to the time of day.

113. (B) An avoidance/acclimation mechanism
When plants encounter water stress, they often undergo morphological changes to cope with the limited water availability. Developing a deeper root system allows the plant to access water from deeper soil layers that remain moist. This type of response is considered an acclimation or avoidance mechanism because it helps the plant maintain its hydration and avoid the harmful physiological consequences of severe water deficit.

114. (A) Is triggered by an initial localized pathogen attack.
Systemic Acquired Resistance is a plant-wide immune response that provides long-lasting protection against a broad spectrum of pathogens. It is initiated following an initial, localized infection that often involves the hypersensitive response. Once triggered, a mobile signal travels from the site of infection to the rest of the plant, activating defense genes and preparing healthy tissues for future attacks by various microbes.

115. (B) Binds to a site other than the active site and changes the enzyme's conformation.
A non-competitive inhibitor reduces the activity of an enzyme by binding to a location known as the allosteric site. This binding is independent of the substrate and does not occur at the active site. The interaction causes a change in the three-dimensional shape of the enzyme, which prevents it from efficiently converting the substrate into product, thus lowering the maximum reaction velocity.

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116. (B) The binding of the substrate induces a conformational change in the enzyme's active site.
The induced-fit model describes a dynamic interaction between an enzyme and its substrate. Unlike the rigid lock-and-key model, this theory proposes that the active site is flexible. As the substrate begins to bind, the enzyme undergoes a subtle conformational change that allows the active site to fit more precisely around the substrate, facilitating the chemical reaction and enhancing the enzyme's catalytic efficiency.

117. (A) III, I, IV, II
Flavonoid biosynthesis begins with the shikimic acid pathway, which provides the necessary precursors for aromatic amino acid synthesis. Phenylalanine is then produced and serves as the primary building block. Subsequently, the enzyme chalcone synthase acts on these precursors to initiate the specific flavonoid pathway. This process eventually leads to the formation of chalcone, which is the basic scaffold for all other flavonoids.

118. (D) Phospholipids are amphipathic lipids that form the bilayer of cell membranes.
Phospholipids are unique molecules characterized by a hydrophilic head and two hydrophobic tails, making them amphipathic. In an aqueous environment, they spontaneously arrange themselves into a bilayer, with the tails facing inward and the heads outward. This structure forms the fundamental framework of

101. (D) Oxidation
The Calvin cycle consists of three primary phases: carboxylation, where carbon dioxide is attached to RuBP; reduction, where the resulting molecules are transformed using ATP and NADPH; and regeneration, where RuBP is recreated to continue the cycle. While oxidation-reduction reactions occur during the reduction phase, oxidation itself is not a distinct, named phase of the carbon-fixing cycle in plants.

102. (A) Both Statement I and Statement II are true.
The chemiosmotic hypothesis describes how ATP is synthesized in both chloroplasts and mitochondria. Both organelles utilize an electron transport chain to move electrons through various membrane proteins. This movement provides the energy to pump protons across the membrane, establishing an electrochemical gradient. The potential energy stored in this gradient then drives the rotation of ATP synthase to generate ATP from ADP.

103. (C) Phosphofructokinase
Phosphofructokinase is a key regulatory enzyme in the glycolysis pathway. It catalyzes the irreversible phosphorylation of fructose-6-phosphate into fructose-1,6-bisphosphate using one molecule of ATP. This step is considered a major control point because the enzyme's activity is sensitive to the cell's energy status, being inhibited by high levels of ATP and stimulated by products that signal low energy availability.

104. (D) 2 CO_2, 1 ATP (or GTP), 3 NADH, 1 FADH2
The citric acid cycle completes the oxidation of glucose derivatives. For every molecule of acetyl-CoA that enters the cycle, two molecules of carbon dioxide are released as waste products. Additionally, the cycle generates high-energy electron carriers in the form of three NADH molecules and one FADH2 molecule. A single molecule of ATP, or its equivalent GTP, is also produced through substrate-level phosphorylation.

105. (A) Amino acids
Plants absorb inorganic nitrogen in the form of nitrate or ammonium and must convert it into an organic form for use. This assimilation process is vital because nitrogen is a major component of amino acids, which are the building blocks of proteins. These proteins serve diverse roles as enzymes, structural components, and signaling molecules, making amino acid synthesis a primary metabolic priority.

106. (C) Gibberellin
Gibberellins are a class of plant hormones that are essential for promoting stem elongation. Dwarfism in many plant species is often caused by a deficiency in gibberellin synthesis or perception. When these dwarf plants are treated with exogenous gibberellins, they often grow to a normal height. This response demonstrates the critical role these hormones play in regulating the growth and stature of plants.

107. (D) Structural components like calcium
During leaf senescence, plants systematically break down and recycle valuable nutrients such as nitrogen, phosphorus, and potassium. These mobile elements are transported through the phloem to younger tissues or storage organs. In contrast, structural components like calcium are largely immobile in the phloem and remain within the leaf's cell walls. Consequently, these structural materials are the last to be removed or are lost entirely when the leaf falls.

108. (C) Efflux carrier proteins.
Polar auxin transport is a directed movement of auxin from the shoot tip down toward the roots. This one-way flow is achieved through the coordinated action of specialized auxin efflux carrier proteins, known as PIN proteins, which are asymmetrically localized on the plasma membrane of cells. These proteins ensure that auxin exits the cell primarily at its basal end, maintaining a precise hormonal gradient.

109. (D) Pfr is converted to Pr by exposure to far-red light or by synthesis in the dark.
Phytochrome exists in two photo-interconvertible forms. The Pr form absorbs red light and is converted to the biologically active Pfr form. Conversely, Pfr absorbs far-red light and is converted back to the Pr form. While Pfr can slowly revert to Pr in the dark, the initial synthesis of phytochrome in developing plant tissues always produces the protein in the inactive Pr form.

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92. (B) Carrier proteins and metabolic energy.
Transporting solutes against a concentration gradient is a process known as active transport. This mechanism cannot occur spontaneously and requires the assistance of specialized carrier proteins or pumps embedded in the membrane. Furthermore, the process must be powered by metabolic energy, typically in the form of ATP, to overcome the natural tendency of molecules to move toward regions of lower concentration.

93. (D) All I, II, and III
Stomatal movement is a complex process regulated by various internal and external factors. The active transport of potassium ions into guard cells lowers their water potential, leading to water uptake and opening. Blue light serves as a specific signal that triggers this opening. Conversely, the hormone abscisic acid acts during stress to promote the efflux of ions and stomatal closure.

94. (D) Apoplastic loading
In many plant species, sucrose must move from the companion cells into the sieve-tube elements against a steep concentration gradient. This process often involves the secretion of sucrose into the cell wall space, or apoplast, before it is actively taken up by the sieve elements using specialized transporters. This energy-dependent mechanism is a classic example of apoplastic phloem loading.

95. (A) Nitrogen is a component of nucleic acids, proteins, and chlorophyll.
Nitrogen is a fundamental macronutrient required by plants for the synthesis of vital biological molecules, including amino acids, proteins, and DNA. It is also a central component of the chlorophyll molecule, which is essential for photosynthesis. Other elements like magnesium are macronutrients, while molybdenum is a micronutrient. Additionally, some elements like calcium are notably immobile within the plant's phloem.

96. (A) P-4, Q-3, R-2, S-1
Nitrogen is a fundamental part of amino acids and proteins. Phosphorus is a critical component of energy-carrying molecules like ATP and the structure of nucleic acids. Potassium plays a key role in maintaining cell turgor and regulating the opening and closing of stomata. Magnesium is uniquely positioned as the central atom in the chlorophyll molecule, which is essential for capturing light.

97. (B) Pigment molecules like chlorophyll and carotenoids
Photosynthesis begins with the absorption of photons by specialized pigment molecules, primarily chlorophyll a and b, as well as accessory pigments like carotenoids. These pigments are organized into light-harvesting complexes within the thylakoid membranes. When light strikes these molecules, they become excited and transfer that energy to the reaction center, initiating the conversion of light energy into chemical energy.

98. (A) Plastoquinone and the cytochrome b6f complex
In the photosynthetic electron transport chain, electrons are energized at photosystem II and then passed through a series of carriers. Plastoquinone and the cytochrome b6f complex facilitate the movement of these electrons toward photosystem I. This transfer is also coupled with the pumping of protons into the thylakoid lumen, creating the gradient necessary for the synthesis of ATP through photophosphorylation.

99. (C) Initial CO_2 fixation step and leaf anatomy.
The primary distinction between C3 and C4 plants involves their method of initial carbon capture and their internal structure. C3 plants fix carbon dioxide directly into a three-carbon compound within mesophyll cells. In contrast, C4 plants use PEP carboxylase to create a four-carbon acid in the mesophyll and possess specialized Kranz anatomy to concentrate carbon dioxide near RuBisCO in bundle sheath cells.

100. (A) Both A and R are true and R is the correct explanation of A.
Photorespiration is often considered a wasteful process because it works against the efficiency of photosynthesis in C3 plants. This pathway consumes energy in the form of ATP and NADH without producing any sugar. Furthermore, it results in the loss of carbon that was previously fixed by the plant. These factors explain why it reduces overall agricultural productivity in certain environments.

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all biological membranes, providing a selective barrier that is essential for maintaining the integrity and function of cells.

119. (B) Mevalonic acid pathway
Rubber is a complex polyterpene composed of thousands of repeating isoprene units. Like most other terpenoids, the biosynthesis of these units primarily occurs through the mevalonic acid pathway in the cytosol or the MEP pathway in plastids. These pathways produce the five-carbon building blocks that are subsequently polymerized by specialized enzymes to form the long, elastic chains characteristic of natural rubber.

120. (A) Both A and R are true and R is the correct explanation of A.
Many plants produce secondary metabolites, such as alkaloids, terpenes, and phenols, as part of a sophisticated defense strategy. These compounds are often bitter, unpalatable, or chemically toxic to animals and insects. By deterring herbivores from feeding, these specialized metabolites reduce tissue damage and increase the plant's chances of survival and reproduction in environments where herbivory is a significant threat.

121. (A) A water potential gradient
Water movement from the soil into the roots is a spontaneous process driven by a gradient in water potential. Because the concentration of solutes is generally higher inside the root cells than in the surrounding soil, the water potential of the roots is more negative. Water naturally moves down this gradient from the higher potential in the soil to the lower potential in the xylem.

122. (A) Both Statement I and Statement II are true.
The Casparian strip is a specialized, water-impermeable band of suberin located in the endodermal cell walls. It effectively blocks the apoplastic movement of water and dissolved minerals through the cell walls into the vascular tissue. This forces all substances to enter the symplast by crossing a plasma membrane, allowing the plant to selectively regulate the uptake of specific ions and nutrients.

123. (C) Through either symplastic or apoplastic pathways, depending on the sink type.
Phloem unloading refers to the process where photoassimilates, like sucrose, exit the sieve tubes and enter the surrounding sink tissues. The specific pathway used varies depending on the species and the type of sink. For example, some sinks use plasmodesmata for symplastic movement, while others require sugars to enter the apoplast before being actively transported into cells, providing metabolic flexibility.

124. (A) Stunted growth and general chlorosis, especially in older leaves.
Nitrogen is a mobile nutrient within the plant, meaning it can be translocated from older tissues to younger, actively growing parts. Consequently, when nitrogen is scarce, the plant sacrifices the older, lower leaves to support new growth. This leads to a characteristic yellowing, or chlorosis, in the older leaves first, accompanied by a significant reduction in overall plant size and vigor.

125. (A) ATP and NADPH
The light-dependent reactions of photosynthesis occur in the thylakoid membranes of the chloroplast. As light energy is captured and electrons flow through the transport chain, a proton gradient is established. This gradient is used to synthesize ATP. Simultaneously, the final transfer of electrons to NADP+ produces NADPH. These two high-energy molecules provide the necessary chemical energy and reducing power for the Calvin cycle.

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126. (A) P-3, Q-1, R-2, S-4
Rice is a C3 plant where carbon fixation occurs directly via RuBisCO in mesophyll cells. Maize is a C4 plant characterized by specialized Kranz anatomy. Pineapple utilizes CAM, which features a temporal separation of carbon fixation and the Calvin cycle to conserve water. Photorespiration is a process that typically occurs at high rates in C3 plants under hot and dry conditions.

127. (C) It directly consumes oxygen.
The citric acid cycle, or Krebs cycle, is a hub of cellular metabolism that completes the oxidation of organic fuels. It produces high-energy electron carriers like NADH and FADH2, which are essential for the electron transport

This inhibition can be overcome by increasing substrate concentration.

74. (C) I and III only
Allosteric enzymes are complex proteins that often consist of multiple subunits and are regulated by molecules binding to sites other than the active site. The binding of an allosteric activator enhances the enzyme's activity, whereas an inhibitor reduces it. Because these regulators do not bind to the active site itself, the statement suggesting they bind there is incorrect according to standard biochemical principles.

75. (D) An amino acid
Proteins are essential biological macromolecules composed of long chains of amino acids. These amino acids are the fundamental building blocks, each containing an amino group, a carboxyl group, and a unique side chain. The specific sequence and properties of these amino acids determine the final three-dimensional structure and the biological function of the protein within the plant cell.

76. (B) Starch
Starch is a high-molecular-weight polysaccharide composed of glucose units and serves as the primary energy storage molecule in plants. It is typically stored as granules within specialized organelles called amyloplasts or in chloroplasts. When the plant requires energy, enzymes break down the starch back into glucose, providing a readily available source of fuel for metabolic processes and growth.

77. (C) Statement I is true, but Statement II is false.
Lipids are a diverse group of non-polar molecules, including fats and oils, characterized by their hydrophobic nature. While phospholipids are essential components of all cellular membranes, they are not the primary building blocks of plant cell walls. Instead, plant cell walls are mainly composed of structural carbohydrates like cellulose, hemicellulose, and pectin, which provide rigidity and support.

78. (D) Peptide bond
Amino acids are linked together to form proteins through the formation of peptide bonds. This covalent bond is created through a dehydration synthesis reaction between the carboxyl group of one amino acid and the amino group of another. As more amino acids are added, they form a long polypeptide chain, which eventually folds into a functional three-dimensional protein structure.

79. (A) Guanine
Nucleic acids, such as DNA and RNA, are composed of nitrogenous bases, sugars, and phosphate groups. The nitrogenous bases are categorized into purines and pyrimidines. Guanine and adenine are the two primary purines found in both DNA and RNA. In contrast, cytosine, thymine, and uracil are pyrimidines. These bases are essential for the storage and transmission of genetic information.

80. (B) Organic molecules required in small amounts, often acting as coenzymes.
Vitamins are essential organic compounds that plants and other organisms require in very small quantities to maintain normal physiological functions. They do not serve as primary energy sources but instead often function as precursors to coenzymes. Coenzymes are vital for the activity of many enzymes, assisting in various metabolic reactions such as energy production and the synthesis of essential molecules.

81. (B) Hydrogen bonds between backbone atoms
The secondary structure of a protein refers to local folding patterns like alpha-helices and beta-sheets. These structures are stabilized by hydrogen bonds that form between the carbonyl oxygen and the amide hydrogen of the polypeptide backbone. While other interactions contribute to the overall protein shape, these specific hydrogen bonds are the primary force maintaining the regular repeating patterns of the secondary structure.

82. (A) Lipid - Monosaccharide
Biomolecules are typically polymers made up of smaller repeating units called monomers. Proteins are composed of amino acids, while starch is a polymer of glucose, a type of monosaccharide. Nucleic acids are built from nucleotides. However, lipids are not traditional polymers made of monosaccharides; instead, they are composed of varied components such as fatty acids and glycerol.

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catalysis. Changes in pH can alter these charges, disrupting the interactions between the enzyme and substrate or changing the overall three-dimensional shape of the protein.

137. (C) Nucleic Acids - Information storage and transfer
Biomolecules are categorized into four major groups, each with a distinct and vital role. Carbohydrates primarily provide energy and structural support. Proteins are involved in catalysis, transport, and signaling. Lipids are essential for membrane structure and long-term energy storage. Nucleic acids, specifically DNA and RNA, are unique because they store and transmit the genetic instructions necessary for the growth and reproduction of all life.

138. (A) Defense against herbivores and pathogens.
Many plants produce specific terpenes, such as menthol and limonene, as part of their secondary metabolism. These compounds often have strong odors and bitter tastes that act as chemical deterrents against insects and other herbivores. Additionally, some of these terpenes possess antimicrobial properties that help protect the plant from fungal and bacterial infections, serving as a vital component of the plant's chemical defense system.

139. (A) Attract pollinators and seed dispersers.
Flavonoids are a diverse group of phenolic compounds that contribute significantly to the vibrant colors of many flowers and fruits. These pigments, including anthocyanins, produce red, blue, and purple hues that serve as visual signals to attract bees, birds, and other animals. By attracting these visitors, flavonoids facilitate essential processes such as pollination and the dispersal of seeds, which are critical for plant reproduction.

140. (C) They are considered primary metabolites essential for all plant life.
Nitrogenous compounds like alkaloids and cyanogenic glycosides are categorized as secondary metabolites. Unlike primary metabolites, which are involved in fundamental processes like respiration and growth in all plants, secondary metabolites are often produced by specific species for specialized roles. Their primary function is typically ecological, such as defending the plant against herbivores or pathogens, rather than supporting basic cellular maintenance or primary development.

141. (B) Aquaporins
Water movement across cell membranes occurs through the lipid bilayer and specialized protein channels called aquaporins. These integral membrane proteins form selective pores that allow water molecules to flow rapidly in response to osmotic gradients. By regulating the number and activity of aquaporins, plant cells can precisely control their water permeability, which is essential for maintaining turgor and responding to environmental water stress.

142. (B) Attraction of water molecules to each other.
The cohesion-tension theory explains the long-distance transport of water in the xylem. The concept of cohesion refers to the strong hydrogen bonds that cause water molecules to stick to one another. This mutual attraction creates a continuous, unbroken column of water from the roots to the leaves. When transpiration pulls water out of the leaves, this cohesive column is drawn upward through the plant.

143. (A) Mobile in the phloem
When a plant experiences a nutrient deficiency, the location of the initial symptoms provides a clue about the nutrient's mobility. If a nutrient can be easily transported through the phloem, the plant will move it from the older, established leaves to the younger, developing ones. This results in chlorosis or other deficiency symptoms appearing first in the older, lower leaves as their nutrient supply is depleted.

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144. (B) mesophyll; bundle sheath
C4 photosynthesis is characterized by a spatial separation of its metabolic steps. Initial carbon fixation occurs in the mesophyll cells, where carbon dioxide is incorporated into a four-carbon acid. This acid is then transported into the specialized bundle sheath cells. Once inside, the acid is broken down to release concentrated carbon dioxide, which is then used by RuBisCO in the standard Calvin cycle reactions.

145. (A) Both A and R are true and R is the correct explanation of A.
Cyclic electron flow is a specialized pathway in photosynthesis that involves only photosystem I and produces ATP without the simultaneous production of NADPH. This process is essential because the Calvin cycle requires more ATP than NADPH for its reactions. By switching to cyclic flow, the plant can adjust the ratio of these high-energy molecules to meet its specific metabolic demands under varying conditions.

146. (D) All of the above.
Respiration and photorespiration are distinct metabolic processes with opposite outcomes. Respiration occurs in all cells to produce ATP and releases carbon dioxide. In contrast, photorespiration is specific to photosynthetic cells in light, consumes ATP, and releases previously fixed carbon dioxide. While respiration is essential for energy production, photorespiration is generally considered a wasteful process because it consumes energy and loses carbon.

147. (D) Statement I is false, but Statement II is true.
Glycolysis is a cytoplasmic pathway that converts one molecule of glucose into two molecules of pyruvate. It does not produce acetyl-CoA directly. Instead, the pyruvate must be transported into the mitochondrial matrix, where it undergoes the link reaction. This specific step, also known as pyruvate decarboxylation, converts pyruvate into acetyl-CoA, which then enters the citric acid cycle for further oxidation.

148. (C) Glutamate synthase
The GS-GOGAT pathway is the primary route for nitrogen assimilation in plants. GOGAT stands for glutamine-2-oxoglutarate aminotransferase, which is also commonly known as glutamate synthase. This enzyme catalyzes the transfer of an amide group from glutamine to 2-oxoglutarate, producing two molecules of glutamate. This reaction is essential for incorporating inorganic nitrogen into amino acids, which are the building blocks of proteins.

149. (A) auxin; lateral
Apical dominance is a phenomenon where the growth of the main central stem is prioritized over lateral branching. This process is regulated by auxin, which is produced in the shoot apical bud and transported downward. The high concentration of auxin in the stem prevents the development of lateral buds. If the apical bud is removed, auxin levels drop, allowing the lateral buds to grow.

150. (A) II, III, IV, I
Vernalization begins when a plant is exposed to a prolonged period of low temperature. This cold treatment triggers a stable epigenetic change at the flowering-locus C. As a result of this molecular shift, the meristem becomes competent to flower. Once the plant has undergone these physiological changes, flowering is successfully promoted later in the season when environmental conditions become favorable for reproduction.

151. (B) P-4, Q-2, R-1, S-3
Auxin is primarily responsible for promoting apical dominance and cell elongation. Cytokinins are essential for stimulating cell division, also known as cytokinesis. Gibberellins play a vital role in breaking seed dormancy and inducing stem elongation. Abscisic acid acts as a stress hormone, promoting the closure of stomata and inducing dormancy in seeds and buds to help the plant survive unfavorable conditions.

152. (B) Red-light induced seed germination
Low fluence responses are a category of phytochrome-mediated effects that are triggered by relatively small amounts of light. A classic example is the induction of seed germination by red light, which can be reversed by a subsequent pulse of far-red light. This sensitivity allows seeds to detect when they are near the soil surface and exposed to enough light to support successful seedling growth.

153. (B) Heat-shock proteins (HSPs)
When plants are exposed to high temperatures that threaten cellular integrity, they rapidly synthesize a specialized group of molecules called heat-shock proteins. These proteins function as molecular chaperones, assisting in the proper folding of newly synthesized proteins and preventing the aggregation of denatured proteins. This response is essential for maintaining cellular function and protecting the plant from the damaging effects of extreme heat stress.

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154. (B) Vmax is unchanged, Km is increased.
A competitive inhibitor competes with the substrate for the active site of an enzyme. Because it does not affect the actual catalytic ability of the enzyme once the substrate is bound, the maximum reaction velocity remains unchanged. However, more substrate is needed to achieve the same rate as in the absence of the inhibitor, which is reflected as an increase in the Michaelis constant.

155. (C) Fructose
Monosaccharides are the simplest form of carbohydrates and cannot be hydrolyzed into smaller sugars. Fructose and glucose are common examples of these single-unit sugars. In contrast, sucrose and lactose are disaccharides composed of two sugar units, while starch is a complex polysaccharide made of many glucose molecules. Fructose is a vital energy source and a major component of fruit and honey.

156. (B) RNA; DNA
Nucleic acids are composed of four different nitrogenous bases. In DNA, the genetic information is stored using adenine, guanine, cytosine, and thymine. However, in RNA, which is involved in translating that genetic information into proteins, uracil is used instead of thymine. This specific difference is one of the key structural features that distinguish the two types of nucleic acids found in living cells.

157. (A) Amino acid metabolism
Alkaloids are a diverse class of nitrogen-containing secondary metabolites that play significant roles in plant defense. Their complex chemical structures are built using building blocks derived from primary metabolism, specifically from amino acids such as lysine, tyrosine, and tryptophan. Through specialized enzymatic pathways, these amino acids are transformed into various alkaloids that often possess potent physiological and pharmacological properties in animals and humans.

158. (B) Making the tissue physically tough and indigestible.
Lignin is a complex and highly durable polymer that is incorporated into the secondary cell walls of plants. By reinforcing these walls, lignin provides the structural rigidity necessary for upright growth. This also serves as an effective defense mechanism because the tough, carbon-rich structure is extremely difficult for most herbivores and microbes to digest, thereby deterring feeding and preventing pathogen entry.

159. (C) High root pressure and low transpiration
Guttation is the appearance of water droplets on the edges of leaves, typically occurring at night or in the early morning. This phenomenon happens when soil moisture is high, creating significant root pressure that pushes water upward. If the humidity is also high, transpiration is low, so the excess water is forced out through specialized structures called hydathodes at the leaf margins.

160. (D) All I, II, and III
Phloem transport is a dynamic process characterized by the bidirectional movement of nutrients, allowing the plant to move sugars from source tissues to various sinks. These source-sink relationships are flexible and change as the plant develops. This translocation is powered by a pressure gradient, as described by the pressure-flow hypothesis, ensuring that energy-rich molecules are distributed efficiently throughout the entire plant.

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161. (B) Is required for the plant to complete its life cycle.
For a mineral element to be classified as essential, it must meet specific criteria. The most fundamental requirement is that the plant cannot complete its life cycle, from germination to seed production, in the absence of that element. Additionally, the element must have a clear physiological role and cannot be completely replaced by another element, highlighting its unique importance in plant metabolism.

162. (A) Photolysis
Photolysis is a critical part of the light-dependent reactions of photosynthesis that occurs in the thylakoid lumen. Using the energy from absorbed light, water molecules are split into their component parts. This reaction releases electrons that are used to replenish photosystem II, protons that contribute to the electrochemical gradient, and oxygen gas, which is released into the atmosphere as a byproduct.

reserves to support the growth of new shoots during the spring.

215. (C) -0.4 MPa
The total water potential of a plant cell is calculated by summing the solute potential and the pressure potential. In this case, adding the negative solute potential of -0.9 MPa to the positive pressure potential of 0.5 MPa results in a total water potential of -0.4 MPa. This negative value indicates that water would move into this cell from an environment with a higher, or less negative, water potential.

216. (D) Molybdenum (Mo)
Nitrate reductase is a critical enzyme in the nitrogen assimilation pathway, responsible for converting nitrate into nitrite. For this enzyme to function, it must have a molybdenum atom at its catalytic center, which is provided by a specialized molybdenum cofactor. This requirement makes molybdenum an essential micronutrient for plants, as its absence would prevent the successful utilization of nitrate as a source of nitrogen for growth.

217. (A) Both A and R are true and R is the correct explanation of A.
In C3 plants, photorespiration increases significantly at higher temperatures and under high oxygen concentrations. This happens because the enzyme RuBisCO cannot perfectly distinguish between carbon dioxide and oxygen. As the temperature rises, the solubility of carbon dioxide decreases faster than that of oxygen, and the enzyme's relative affinity for oxygen increases. This leads to a higher rate of oxygenation and more wasteful photorespiratory activity.

218. (A) ATP
The regeneration phase is the final stage of the Calvin cycle, where the starting molecule ribulose-1,5-bisphosphate is recreated. This complex series of reactions involves the conversion of several three-carbon sugars back into five-carbon molecules. The final step of this phase specifically requires the addition of a phosphate group, which is provided by one molecule of ATP, ensuring the cycle can continue to fix more carbon dioxide.

219. (B) The flow of protons down an electrochemical gradient through ATP synthase.
The chemiosmotic theory, proposed by Peter Mitchell, describes how ATP is generated in both chloroplasts and mitochondria. As electrons move through a transport chain, energy is used to pump protons across a membrane, creating a high concentration on one side. The potential energy of this electrochemical gradient is then captured as the protons flow back through the enzyme ATP synthase, which catalyzes the production of ATP from ADP.

220. (B) Beta-oxidation and the Glyoxylate Cycle
Germinating seeds often rely on stored lipids as their primary energy source. These lipids are first broken down into fatty acids, which then undergo beta-oxidation in specialized organelles called glyoxysomes. The resulting acetyl-CoA is processed through the glyoxylate cycle to produce four-carbon compounds. These compounds are finally converted into sugars through gluconeogenesis, providing the necessary energy and building blocks for the developing seedling before it can perform photosynthesis.

221. (D) All I, II, and III
Plants are capable of synthesizing all twenty common amino acids required for building their proteins. The carbon frameworks for these amino acids are provided by intermediates diverted from primary metabolic pathways like glycolysis and the citric acid cycle. Meanwhile, nitrogen is incorporated into these skeletons primarily through the GS-GOGAT pathway. This biosynthetic self-sufficiency is a fundamental characteristic that distinguishes plants from most animals and humans.

222. (D) Increased polar transport of auxin.
When a dark-grown seedling is first exposed to light, it undergoes a series of rapid developmental changes known as de-etiolation. These include the expansion of cotyledons, the synthesis of chlorophyll, and a significant reduction in the rate of stem elongation. While these processes are coordinated by various hormones and photoreceptors, a general increase in the polar transport of auxin is not a characteristic part of this light-triggered "greening" response.

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speed up as temperature rises, the internal oscillator of the clock is designed to resist these changes. This ensures that the plant's timing remains accurate and reliable across different seasons and weather conditions.

172. (A) Both A and R are true and R is the correct explanation of A.
Long-day plants require a short night to trigger flowering. By providing a brief flash of red light during the middle of a long night, the plant's phytochrome system is converted from the inactive Pr form to the active Pfr form. This light pulse tricks the plant into perceiving the dark period as having been interrupted, effectively simulating a short-night condition and inducing flowering.

173. (A) PAMP-triggered immunity (PTI)
Plants possess an innate immune system that recognizes common molecules shared by many microbes, known as Pathogen-Associated Molecular Patterns. When cell-surface receptors detect these patterns, they activate PAMP-triggered immunity. This initial layer of defense involves the reinforcement of cell walls, the production of reactive oxygen species, and the activation of defense genes to provide a basal level of resistance against many potential pathogens.

174. (B) Compatible solutes or osmolytes
When plants encounter salt stress, they often sequester sodium and chloride ions into the vacuole to prevent toxicity. To prevent the cytoplasm from losing water to the vacuole, the cell must synthesize and accumulate compatible solutes like proline or sugar alcohols. These osmolytes balance the osmotic potential of the cytoplasm without interfering with cellular metabolism, allowing the plant to maintain turgor and function.

175. (B) Interactions between the R-groups of the amino acids.
The tertiary structure of a protein refers to its complete three-dimensional shape, which is essential for its biological function. This folding is primarily driven and stabilized by various interactions between the side chains, or R-groups, of the amino acids. These include hydrogen bonds, ionic bridges, hydrophobic interactions, and covalent disulfide bonds, which collectively ensure that the protein stays in its correct functional configuration.

176. (C) Cellulose
Cellulose is a structural polysaccharide composed of linear chains of glucose molecules. It is the most abundant organic compound on Earth and forms the primary component of plant cell walls. The arrangement of these chains into microfibrils provides the high tensile strength and rigidity necessary to support the plant body. Unlike starch, which is used for energy, cellulose is specifically designed for physical structure.

177. (A) P-3, Q-1, R-4, S-2
Proteins are defined by the peptide bonds that link their amino acids together. DNA is characterized by its iconic double helix structure, which stores genetic information. Starch is a large carbohydrate formed by glucose units joined by glycosidic bonds. Phospholipids are essential components of cell membranes because of their amphipathic nature, possessing both water-attracting and water-repelling regions in a single molecule.

178. (B) It causes conformation changes.
An allosteric inhibitor regulates enzyme activity by binding to a specific site other than the active site. This interaction induces a conformational change in the protein's structure, which alters the shape of the active site. As a result, the enzyme's ability to bind the substrate or catalyze the reaction is significantly reduced, providing the cell with a mechanism to control metabolic pathways through feedback.

179. (C) Menthol
Terpenes are classified based on the number of five-carbon isoprene units they contain. Monoterpenes are composed of two of these units, giving them a total of ten carbon atoms. Menthol is a classic example of a monoterpene and is known for its strong scent and cooling properties. Larger terpenoids, like carotenoids and rubber, contain significantly more carbon atoms and serve different biological functions.

180. (B) Aromatic amino acids and phenolic compounds
The shikimic acid pathway is a fundamental metabolic route in plants that leads to the synthesis

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of the aromatic amino acids phenylalanine, tyrosine, and tryptophan. These amino acids serve as the essential precursors for a vast array of secondary metabolites, including phenolic compounds like lignin, tannins, and flavonoids. This pathway is a critical link between primary metabolism and the production of defensive and structural molecules.

181. (A) Solute potential (Ψs)
In an open container at standard atmospheric pressure, the pressure potential is considered to be zero. Therefore, the total water potential of a solution is determined by the amount of dissolved substances it contains. As solutes are added to the water, they lower its free energy, which is reflected as a more negative solute potential. This value becomes the primary driver of the overall water potential.

182. (D) Ion Channel - Protein carrier, requires energy, follows gradient
Ion channels are specialized pore-forming proteins that allow specific ions to move across the cell membrane. This movement is a form of passive transport, as the ions flow down their electrochemical gradient without the direct expenditure of metabolic energy. Describing an ion channel as requiring energy is incorrect, as that property characterizes active transport pumps rather than the facilitated diffusion observed in channels.

183. (A) III, IV, I, II
Carbon dioxide fixation in C4 plants begins with the conversion of bicarbonate by PEP carboxylase in mesophyll cells. The resulting four-carbon acid is then transported to the bundle sheath cells. In these specialized cells, the acid undergoes decarboxylation to release carbon dioxide. Finally, this concentrated carbon dioxide is fixed by the enzyme RuBisCO through the standard reactions of the Calvin cycle to produce sugars.

184. (A) Non-photochemical quenching (NPQ)
Non-photochemical quenching is a vital mechanism that plants use to protect themselves from excessive light. When light intensity exceeds the capacity of photosynthesis, the energy could cause damage. NPQ allows the plant to safely dissipate this excess excitation energy as heat. This process is primarily regulated by changes in the pH of the thylakoid lumen and the conversion of pigments within the xanthophyll cycle.

185. (B) Ribulose-1,5-bisphosphate and CO_2
RuBisCO is the primary enzyme responsible for fixing inorganic carbon into organic matter. Its substrates are carbon dioxide and the five-carbon sugar ribulose-1,5-bisphosphate. During the carboxylation reaction, the enzyme attaches the carbon dioxide to the sugar, creating an unstable six-carbon intermediate that quickly splits into two molecules of 3-phosphoglycerate. This reaction is the first and most critical step of the Calvin cycle.

186. (B) Oxidative phosphorylation
While glycolysis and the citric acid cycle produce a small amount of ATP directly, the vast majority of cellular energy is generated during oxidative phosphorylation. This process occurs in the inner mitochondrial membrane, where high-energy electrons from NADH and FADH2 are passed through the transport chain. This flow drives the pumping of protons, creating a gradient that powers ATP synthase to produce large quantities of ATP.

187. (C) The citric acid cycle produces NADH and FADH2, which donate electrons to the electron transport chain.
The citric acid cycle and the electron transport chain are functionally connected within the mitochondria. As the cycle oxidizes organic molecules, it captures released energy by reducing NAD+ and FAD into NADH and FADH2. these molecules then travel to the inner membrane, where they deliver high-energy electrons to the transport chain. This electron transfer is the essential first step that ultimately leads to ATP production.

188. (A) Both A and R are true and R is the correct explanation of A.
Polar transport of auxin is fundamental for organizing plant growth and directing responses to environmental signals like gravity and light. This one-way movement is controlled by the asymmetric placement of PIN proteins, which act as auxin efflux carriers on the cell membrane. By directing the flow of auxin from cell to cell, these proteins create the hormonal gradients necessary for proper development.

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189. (D) Inducing seed dormancy
Cytokinins are versatile plant hormones that promote cell division, coordinate the growth of lateral buds, and help delay the aging of leaves. They generally work in opposition to abscisic acid, which is the primary hormone responsible for inducing and maintaining seed dormancy. Therefore, suggesting that cytokinins induce dormancy is incorrect, as their biological role is typically associated with active growth and the promotion of developmental processes.

190. (B) Photoperiodism is a response to day length, while vernalization is a response to cold temperature.
Photoperiodism and vernalization are two distinct environmental sensing mechanisms that plants use to time their flowering. Photoperiodism involves measuring the relative length of day and night to sense the season. In contrast, vernalization is the process where flowering is induced specifically by a prolonged period of exposure to cold. Both systems ensure that the plant reproduces at the most advantageous time of year.

191. (D) All I, II, and III
Plants utilize multiple photoreceptors to monitor their light environment. Phytochromes, cryptochromes, and phototropins each serve distinct roles in growth and development. While phytochromes sense red and far-red light, cryptochromes are blue-light receptors involved in circadian rhythms. Phototropins also absorb blue light and are essential for mediating stomatal opening. These statements accurately reflect the diversity and function of plant light sensors.

192. (B) A highly specific recognition of pathogen effector proteins by plant R (resistance) proteins.
Effector-triggered immunity is a sophisticated layer of the plant immune system. It occurs when specific resistance proteins within the plant cell recognize effector molecules that have been secreted by a pathogen to suppress basal defenses. This recognition is highly specific and often leads to a rapid hypersensitive response, effectively stopping the infection through localized cell death and the activation of stronger systemic defenses.

193. (B) Loss of its secondary, tertiary, and quaternary structure and thus its function.
Denaturation is a process where an enzyme's complex three-dimensional shape is disrupted due to external stress, such as extreme temperature or pH changes. While the primary sequence of amino acids remains intact, the folding that creates the active site is lost. Because an enzyme's function is entirely dependent on its specific shape, denaturation results in a complete loss of its ability to catalyze reactions.

194. (C) Adenine pairs with thymine (in DNA) and guanine pairs with cytosine.
In the double-stranded DNA molecule, the nitrogenous bases follow specific base-pairing rules that ensure accurate genetic coding. Adenine always forms hydrogen bonds with thymine, while guanine consistently pairs with cytosine. This complementary relationship is the foundation for DNA replication and transcription. In RNA, thymine is replaced by uracil, which then pairs with adenine during the formation of temporary RNA-DNA hybrids.

195. (B) Glucose and fructose
Sucrose is the primary carbohydrate transported through the phloem from the leaves to other parts of the plant. It is a disaccharide formed by the covalent linkage of one glucose molecule and one fructose molecule. This sugar is particularly suited for long-distance transport because it is relatively stable and non-reducing, meaning it is less likely to react with other molecules during its journey through the vascular system.

196. (C) The color of flavonoids and the scent of terpenes in flowers.
Secondary metabolites play a vital role in plant reproduction by facilitating communication with animals. Flavonoids, such as anthocyanins, provide the brilliant colors that make flowers visually attractive to pollinators. Simultaneously, volatile terpenes produce the distinct scents that can be detected from a distance. Together, these chemical signals guide pollinators to the flowers, ensuring successful pollen transfer and the subsequent production of seeds.

197. (C) Cyanogenic glycoside
Cyanogenic glycosides are defensive compounds found in many plant species. They are stored in

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163. (B) They open their stomata during the day to maximize CO_2 uptake.
CAM plants have evolved a unique strategy to survive in arid environments by opening their stomata only at night to minimize water loss. During this time, they take up carbon dioxide and store it as malic acid in their vacuoles. During the day, the stomata remain closed while the stored carbon is used for photosynthesis. This temporal separation is a hallmark of their adaptation.

164. (B) Broaden the spectrum of light absorbed and protect chlorophyll from photodamage.
Carotenoids are accessory pigments that enhance the efficiency of photosynthesis by absorbing wavelengths of light that chlorophyll cannot. They then transfer this captured energy to the reaction center. Crucially, carotenoids also play a vital role in photoprotection. They safely dissipate excess light energy as heat, preventing the formation of reactive oxygen species that could otherwise damage the photosynthetic machinery of the plant.

165. (B) Less ATP is produced per oxygen molecule reduced.
The alternative oxidase pathway provides a shortcut in the mitochondrial electron transport chain. Because it bypasses several proton-pumping complexes, fewer protons are moved across the inner membrane for each electron that flows through the system. Consequently, the resulting electrochemical gradient is weaker, leading to a significant reduction in the amount of ATP synthesized compared to the traditional cytochrome-mediated pathway.

166. (A) 2 Pyruvate, 2 ATP, 2 NADH
Glycolysis is the first stage of cellular respiration, occurring in the cytosol. During this process, a single glucose molecule is partially oxidized through a series of ten reactions. This results in the production of two molecules of pyruvate. The pathway also yields a net gain of two ATP molecules through substrate-level phosphorylation and two molecules of NADH, which carry high-energy electrons.

167. (B) Nitrogenase
Biological nitrogen fixation is the vital process of converting atmospheric nitrogen gas into a form that plants can use, such as ammonia. This challenging chemical reaction is catalyzed by the enzyme nitrogenase, which is produced only by certain bacteria and archaea. Nitrogenase is highly sensitive to oxygen and requires significant energy in the form of ATP to break the strong triple bond of nitrogen.

168. (B) Plant B will show more lateral branching than Plant A.
Apical dominance is the physiological phenomenon where the shoot tip produces auxin, which travels down the stem and inhibits the growth of lateral buds. In plant A, this dominance remains intact. In plant B, removing the apical bud eliminates the primary source of auxin. This drop in auxin concentration allows the lateral buds to break dormancy and begin growing, resulting in a bushier appearance.

169. (A) Both Statement I and Statement II are true.
Senescence is an active and energy-dependent process, not simply a passive decay of aging tissues. It is a highly coordinated, genetically programmed phase that allows the plant to systematically break down cellular components. This ensures that valuable nutrients like nitrogen and minerals are recovered and moved to younger leaves or reproductive organs, maximizing the plant's overall reproductive success and nutrient efficiency.

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170. (C) Ethylene
Ethylene is a unique gaseous hormone that regulates many aspects of plant growth and development, including fruit ripening and leaf abscission. Its biosynthesis starts with the amino acid methionine, which is converted into S-adenosylmethionine and then into 1-aminocyclopropane-1-carboxylic acid. The final step, catalyzed by ACC oxidase, produces ethylene. This specific pathway is highly regulated by various environmental and internal signals.

171. (C) The period of the clock remains relatively constant over a range of physiological temperatures.
Temperature compensation is a remarkable feature of the biological clock that allows it to maintain a precise 24-hour cycle despite fluctuations in environmental temperature. While most biochemical reactions significantly

phenomenon often called the Richmond-Lang effect. They work by promoting the mobilization of nutrients to the treated area and maintaining the synthesis of proteins and chlorophyll. Applying exogenous cytokinins to cut flowers can significantly extend their freshness and vase life by slowing down the genetically programmed process of senescence.

207. (B) A protein product of a 'clock gene' inhibiting its own transcription.
The biological clock operates through a sophisticated molecular mechanism known as a transcriptional-translational feedback loop. In this system, certain genes are transcribed to produce proteins that accumulate over time. Once these proteins reach a specific concentration, they travel back into the nucleus and inhibit the transcription of their own genes. This cycle of buildup and inhibition creates the rhythmic 24-hour cycle observed in plant physiology.

208. (B) The lateral redistribution of auxin to the shaded side of the stem.
When phototropins perceive a light gradient, they initiate a signaling pathway that leads to the asymmetric distribution of auxin. Instead of moving straight down the stem, auxin is actively transported toward the shaded side. The resulting higher concentration of auxin on the shaded side stimulates more rapid cell elongation compared to the illuminated side, causing the stem to bend and grow toward the light source.

209. (B) The accumulation of solutes in the cytoplasm to lower the freezing point.
Plants that are tolerant to freezing temperatures employ several biochemical strategies to protect their cells. A primary mechanism involves the synthesis of cryoprotectants, such as sugars and certain amino acids, which accumulate in the cytoplasm. These solutes help to lower the freezing point of the cellular fluid and stabilize membranes and proteins, preventing the lethal formation of ice crystals within the living cell components during extreme cold.

210. (B) P-2, Q-3, R-4, S-1
The maximum reaction rate at substrate saturation is defined as the Vmax. The Michaelis constant, or Km, is the substrate concentration at which the reaction velocity is half of its maximum. Competitive inhibition occurs when an inhibitor resembles the substrate and binds to the active site. In contrast, non-competitive inhibition involves an inhibitor binding to a different site, which reduces the enzyme's catalytic activity.

211. (C) A group of hydrophobic molecules like fats, oils, and waxes.
Lipids are a chemically diverse group of biological molecules that share a common property: they are largely insoluble in water. This hydrophobic nature arises from their high proportion of non-polar carbon-hydrogen bonds. Lipids include triacylglycerols for energy storage, phospholipids for membrane structure, and waxes for protective coatings. Unlike proteins or nucleic acids, they are not typically polymers made of repeating monomeric units.

212. (C) Coenzyme precursors for reactions.
Vitamins are essential organic compounds that plants require in minute quantities for various metabolic processes. They do not provide energy themselves but are vital because they often serve as precursors for coenzymes. These coenzymes bind to enzymes and are directly involved in the chemical transformations of substrates. Without these vitamin-derived cofactors, many critical enzymatic reactions in the cell would proceed too slowly or not at all.

213. (B) Isoprenoid (terpenoid) precursors
Plants utilize two distinct metabolic pathways to produce the five-carbon building blocks required for synthesizing all isoprenoids. The mevalonic acid pathway operates in the cytosol, while the methylerythritol phosphate pathway is located within the plastids. These units are the fundamental precursors for a vast range of compounds, including photosynthetic pigments like carotenoids, growth-regulating hormones like gibberellins, and numerous defensive secondary metabolites.

214. (B) A net exporter of photoassimilates.
In the context of phloem translocation, a source is any part of the plant that produces or releases more sugar than it consumes for its own growth and maintenance. Mature, photosynthetically active leaves are the primary sources in most plants. However, storage organs like tubers can also act as sources when they break down their

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an inactive form within plant cells. However, when the tissue is damaged, such as by a chewing herbivore, these compounds come into contact with specialized enzymes that break them down. This reaction releases hydrogen cyanide, a highly toxic gas that inhibits cellular respiration in the attacker, providing an effective chemical defense.

198. (C) Endodermis
The Casparian strip is a specialized structural feature of the endodermis, which is the innermost layer of the root cortex. This band of suberin and lignin surrounds each endodermal cell, creating a waterproof barrier in the cell wall. This forces water and solutes to cross the plasma membrane to enter the vascular cylinder, allowing the plant to selectively control the uptake of minerals.

199. (A) Both Statement I and Statement II are true.
Phloem unloading at the sink tissues can occur through two primary routes. In the symplastic pathway, solutes like sugars move directly through plasmodesmata that connect the sieve elements to the surrounding cells. Alternatively, the apoplastic pathway involves the secretion of sugars into the cell wall space, from which they are then actively taken up by the sink cells using specialized membrane transporters.

200. (A) The synthesis of chlorophyll and as a component of cytochromes in electron transport chains.
Iron is an essential micronutrient that plays a critical role in cellular energetics. It is a key component of cytochromes and iron-sulfur proteins, which are necessary for electron transport in both photosynthesis and respiration. Furthermore, iron is required for the enzymatic steps involved in the synthesis of chlorophyll, explaining why iron deficiency leads to severe yellowing of the leaves, or chlorosis.

201. (B) Water (H_2O)
During the light-dependent reactions of photosynthesis, water molecules undergo a process called photolysis. This reaction involves the splitting of water into electrons, protons, and molecular oxygen. While carbon dioxide is essential for synthesizing glucose, it does not contribute to the oxygen gas released. Experimental evidence using isotopes has confirmed that all the oxygen evolved during photosynthesis originates strictly from water.

202. (B) HCO3-; O_2
PEP carboxylase is a vital enzyme in C4 and CAM plants that initially fixes carbon by adding bicarbonate to phosphoenolpyruvate. Unlike RuBisCO, this enzyme has a very high affinity for bicarbonate and does not react with oxygen. This allows these plants to efficiently capture carbon even when carbon dioxide levels are low, effectively avoiding the wasteful process of photorespiration that occurs in C3 plants.

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203. (A) NAD+
When oxygen is unavailable, the electron transport chain cannot function, and NADH begins to accumulate. To keep glycolysis running and produce a small amount of ATP, the cell must regenerate NAD+. Fermentation achieves this by transferring electrons from NADH to pyruvate or its derivatives. This process produces byproducts like ethanol or lactic acid while allowing the cell to maintain a basic level of energy production.

204. (D) Carboxylation of PEP in the cytoplasm.
Photorespiration is a complex salvage pathway that involves reactions in the chloroplast, peroxisome, and mitochondrion. It starts with the oxygenation of RuBP and involves the conversion of various intermediates, including the release of carbon dioxide from glycine. However, the carboxylation of PEP is a characteristic step of the C4 and CAM photosynthetic pathways and is not part of the photorespiratory cycle that follows the oxygenase activity of RuBisCO.

205. (B) Mevalonic acid/terpenoid pathway
Gibberellins are a large group of tetracyclic diterpene acids that act as important growth regulators in plants. As members of the terpenoid family, their biosynthesis begins with the formation of five-carbon isoprene units. These building blocks are produced through the mevalonic acid pathway in the cytosol or the MEP pathway in plastids. These units are then polymerized and cyclized to form the complex gibberellin skeleton.

206. (C) Cytokinin
Cytokinins are well-known for their ability to delay the aging process in plant tissues, a

223. (B) The activation of a plasma membrane proton pump (H+-ATPase) in guard cells.
Stomatal opening in response to blue light is a sophisticated process mediated by phototropins. Upon perceiving the light, these receptors initiate a signaling cascade that activates proton pumps in the guard cell plasma membrane. The pumping of protons out of the cell creates an electrochemical gradient that drives the uptake of potassium and other ions. This lowers the water potential, causing water to enter and open the stomata.

224. (C) Having a high capacity for regrowth and compensation after being damaged.
Tolerance is a plant's ability to minimize the negative impact of stress on its overall health and reproduction without necessarily preventing the stress from occurring. In the case of biotic stress from herbivores, a tolerant plant may not have toxins or physical barriers to stop the feeding. Instead, it possesses a high capacity to rapidly regrow and compensate for the lost tissue, allowing it to maintain its fitness despite being attacked.

225. (B) A sigmoidal (S-shaped) curve
Allosteric enzymes exhibit a unique kinetic behavior where the binding of a substrate to one subunit influences the binding to other subunits, a phenomenon known as cooperativity. When the initial reaction velocity is plotted against substrate concentration, this cooperative binding produces a characteristic sigmoidal or S-shaped curve. This is distinct from the hyperbolic curve seen in non-allosteric enzymes and reflects the complex regulatory nature of these multi-subunit proteins.

226. (B) The absence of carbon-carbon double bonds.
The saturation of a fatty acid refers to the presence or absence of double bonds within its long hydrocarbon tail. Saturated fatty acids have no carbon-carbon double bonds, meaning they are "saturated" with the maximum possible number of hydrogen atoms. This structural feature allows the chains to pack tightly together, typically making these fats solid at room temperature. Unsaturated fatty acids, however, contain one or more double bonds.

227. (C) Breaking down upon tissue damage to release pungent and toxic compounds like isothiocyanates.
Glucosinolates are part of a sophisticated "mustard oil bomb" defense system. They are stored separately from the enzyme myrosinase within the plant. When a herbivore bites into the tissue, the cells are ruptured, allowing the glucosinolates and myrosinase to mix. This results in a rapid chemical reaction that releases toxic and pungent products, which act as a powerful deterrent against a wide variety of pests and pathogens.

228. (B) Sink tissue
A sink tissue is any part of the plant that consumes or stores photoassimilates for its own use. Developing storage roots, such as those in carrots or sugar beets, are major sinks because they actively import sugars from the phloem to build up their energy reserves. In these tissues, the concentration of sugars is kept lower than in the phloem, maintaining the pressure gradient necessary for continued translocation.

229. (A) Both Statement I and Statement II are true.
For plants to perform photosynthesis, they must open their stomata to allow carbon dioxide to enter the leaf. However, the same environment that facilitates gas exchange also allows water vapor to escape from the moist interior of the leaf into the drier atmosphere. This unavoidable loss of water, known as transpiration, is a direct consequence of the physical trade-off required to obtain the carbon needed for growth.

230. (C) Casparian strip
Water and minerals moving through the root cortex via the apoplast encounter a final barrier at the endodermis. The Casparian strip, made of impermeable suberin, is embedded in the endodermal cell walls and blocks this pathway. This forces all substances to enter the symplast by crossing the cell's plasma membrane. This mechanism ensures that the plant can selectively regulate the minerals that ultimately enter the xylem and the rest of the plant.

231. (A) Ribulose-1,5-bisphosphate (RuBP)
The Calvin cycle begins with the carboxylation phase, where inorganic carbon dioxide is incorporated into an organic molecule. This

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specific reaction is catalyzed by the enzyme RuBisCO, which attaches the carbon dioxide to a five-carbon sugar called ribulose-1,5-bisphosphate. This process produces an unstable six-carbon intermediate that immediately splits into two molecules of 3-phosphoglycerate, the first stable product of the carbon fixation pathway in C3 plants.

232. (C) It is a highly efficient energy-producing pathway.
Photorespiration is fundamentally a salvage pathway rather than an energy-producing one. It occurs when RuBisCO binds oxygen instead of carbon dioxide, leading to the production of molecules that must be recycled through a series of reactions in three different organelles. This entire process consumes significant amounts of ATP and reducing power while releasing previously fixed carbon, which reduces the overall photosynthetic efficiency and biomass production of the plant.

233. (B) Complex II (Succinate Dehydrogenase)
In the mitochondrial electron transport chain, the energy released as electrons move through the complexes is used to pump protons across the inner membrane. Complexes I, III, and IV all function as proton pumps that contribute to the formation of the electrochemical gradient. Complex II, however, is unique because it transfers electrons to the chain without moving protons, thus contributing less to the overall energy potential used for ATP synthesis.

234. (D) Ethylene
Climacteric fruits are those that experience a significant burst in cellular respiration and ethylene production at the onset of ripening. This hormone, ethylene, acts as the master signal that coordinates the rapid physiological changes such as softening, the development of aroma, and the conversion of starches to sugars. Once triggered by ethylene, this ripening process is self-accelerating and can be easily observed in fruits like bananas, tomatoes, and apples.

235. (A) IV, II, III, I
The phytochrome signaling pathway begins when the pigment absorbs red light, which causes the protein to convert from its inactive Pr form to the active Pfr form. Once activated, the Pfr protein is translocated from the cytoplasm into the nucleus. Inside the nucleus, Pfr interacts with various transcription factors and regulatory proteins. This interaction ultimately leads to a change in the expression of specific genes, initiating the plant's physiological response to the light.

236. (A) Environmental 24-hour day
Entrainment is the process by which a plant's internal biological clock is reset and synchronized with the external environment. This is primarily achieved through daily light and temperature cues, which ensure that the clock's 24-hour cycle perfectly matches the natural day-night cycle. By staying in sync with the environment, the plant can accurately time its metabolic and physiological activities, such as preparing for photosynthesis before sunrise, to maximize its survival and growth.

237. (C) The waxy cuticle on the epidermis
Plants have several layers of defense, and the first line is made up of constitutive physical barriers. The waxy cuticle that covers the outer surface of the epidermis is a prime example. This hydrophobic layer provides a tough, slippery surface that makes it difficult for many pathogens to attach to the plant or penetrate into the underlying tissues. It also helps to prevent the accumulation of water, further reducing the chances of microbial infection.

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238. (B) The protein portion of an enzyme, which is inactive without its cofactor.
Many enzymes require non-protein components called cofactors to become catalytically active. The purely protein part of such an enzyme is referred to as the apoenzyme. On its own, the apoenzyme is inactive because it lacks the necessary chemical groups provided by the cofactor to facilitate the reaction. When the apoenzyme and the appropriate cofactor are combined, they form a fully functional unit known as a holoenzyme.

239. (B) Secondary structure
The secondary structure of a protein describes the local folding and twisting of the polypeptide backbone. These patterns, such as the coiled alpha-helix and the folded beta-sheet, are stabilized by hydrogen bonds that form between the oxygen and nitrogen atoms of the backbone. These regular repeating structures are the first

level of three-dimensional organization and provide the foundation for the more complex tertiary folding of the entire protein.

240. (C) Phenylalanine
Phenolic compounds are a vast and essential group of secondary metabolites in plants, including molecules like lignin, flavonoids, and tannins. Their biosynthesis primarily originates from the aromatic amino acid phenylalanine, which is produced by the shikimic acid pathway. Phenylalanine is then converted by the enzyme phenylalanine ammonia-lyase into cinnamic acid, which serves as the fundamental building block for the wide diversity of phenolic substances found throughout the plant.

241. (A) Turgor pressure gradient between source and sink.
The pressure-flow hypothesis explains that phloem transport is driven by a difference in turgor pressure. At the source, the active loading of sugars lowers the water potential, causing water to enter and increase the turgor pressure. At the sink, the unloading of sugars causes water to exit, lowering the pressure. This resulting gradient creates a bulk flow of sap from the high-pressure source to the low-pressure sink.

242. (C) Magnesium (Mg)
Magnesium is a vital macronutrient for plants, most notably because it serves as the central atom in the porphyrin ring of the chlorophyll molecule. Without a sufficient supply of magnesium, plants cannot produce enough chlorophyll for photosynthesis, leading to a characteristic yellowing of the leaves known as interveinal chlorosis. Since magnesium is a mobile element, these deficiency symptoms typically appear first in the older leaves of the plant.

243. (B) Proteins and pigment molecules like chlorophyll and carotenoids
Light-harvesting complexes are intricate assemblies located within the thylakoid membranes of chloroplasts. They consist of a variety of pigment molecules, including chlorophyll a, chlorophyll b, and carotenoids, all bound to specialized proteins. These complexes act like a biological antenna, capturing light energy from a broad range of wavelengths and funneling that energy toward the reaction center to power the initial steps of the photosynthetic electron transport chain.

244. (B) C4
C4 photosynthesis is a specialized pathway evolved by plants to maximize efficiency in environments with high light intensity and temperatures. These plants initially fix carbon dioxide into a four-carbon compound, such as malate, within their mesophyll cells. This carbon is then transported to specialized bundle sheath cells, where it is released and concentrated for use by the Calvin cycle. This mechanism effectively reduces photorespiration and conserves water in arid conditions.

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245. (B) P-2, Q-4, R-1, S-3
Glycolysis is the initial stage of respiration that occurs in the cytosol. The link reaction serves as a bridge, moving the products of glycolysis from the cytosol into the mitochondrial matrix. Once there, the citric acid cycle completes the oxidation of the fuel molecules. Finally, the electron transport chain, located on the inner mitochondrial membrane, uses the energy from these oxidations to produce the majority of the cell's ATP.

246. (B) GS-GOGAT pathway
The GS-GOGAT pathway is the most important high-affinity system for incorporating inorganic nitrogen into organic compounds in plants. It involves the coordinated action of two enzymes: glutamine synthetase and glutamate synthase. This pathway is particularly efficient because it can function even when ammonium levels are very low, ensuring that the plant has a steady supply of amino acids for the synthesis of proteins and other essential nitrogen-containing molecules.

247. (B) Inhibition of elongation, radial swelling of the stem, and exaggerated apical hook.
The triple response is a specialized growth habit in seedlings triggered by the gaseous hormone ethylene. It is characterized by three distinct morphological changes: the inhibition of stem elongation, the promotion of radial swelling or thickening of the stem, and the exaggeration of the apical hook curvature. This response helps the seedling navigate obstacles in the soil during

daily, ensuring that the plant's activities remain perfectly timed.

281. (B) Abiotic stress like drought or salinity
When plants are exposed to drought or high salinity, they face the challenge of losing water due to osmotic pressure. To combat this, they synthesize and accumulate compatible solutes, which are small organic molecules like proline that do not interfere with normal cellular functions. These solutes lower the osmotic potential of the cytoplasm, allowing the plant to retain water and maintain turgor pressure despite the low water potential of the surrounding environment.

282. (B) The active site has a rigid shape that is complementary to the substrate.
The lock-and-key hypothesis was one of the first models used to explain how enzymes interact with their substrates. It proposes that the enzyme's active site has a specific, rigid three-dimensional shape that perfectly matches the shape of the substrate. Just as a specific key fits into a specific lock, only the correct substrate can bind to the enzyme and undergo a reaction. This model emphasizes the high degree of specificity shown by biological catalysts.

283. (B) Glycosidic bond
A glycosidic bond is a type of covalent linkage that joins a carbohydrate molecule to another group or molecule. In the case of disaccharides like sucrose or maltose, this bond connects two individual monosaccharide units. It is formed through a dehydration synthesis reaction, where a molecule of water is removed as the bond is created. This fundamental linkage is the basis for building all complex carbohydrates and polysaccharides in living organisms.

284. (C) Xylem
Lignin is a complex and extremely durable polymer that is a major component of the secondary cell walls in vascular plants. It is particularly abundant in the xylem tissue, where it provides the necessary structural reinforcement for water-conducting vessels and tracheids. By making these cells rigid and waterproof, lignin allows the plant to grow tall and ensures that water can be transported under tension without the vessels collapsing.

285. (C) Endodermis
For minerals to be transported from the soil into the plant's vascular system, they must eventually pass through the endodermis. This cell layer contains the Casparian strip, which blocks the passive movement of solutes through the cell walls. Therefore, all ions must cross a plasma membrane to enter the symplast of the endodermal cells. This selective barrier allows the plant to control exactly which minerals are allowed to enter the xylem for distribution.

286. (D) CO_2
The light-dependent reactions of photosynthesis use light energy and water to produce chemical energy. The primary products of these reactions are ATP and NADPH, which are then used in the Calvin cycle. Additionally, the splitting of water molecules releases oxygen gas as a byproduct. Carbon dioxide, however, is not a product of these reactions; instead, it is a substrate that is consumed later during the carbon fixation phase.

287. (B) C4 plants have spatial separation of initial CO_2 fixation and the Calvin cycle; CAM plants have temporal separation.
C4 and CAM plants both utilize PEP carboxylase to avoid photorespiration, but they differ in how they organize their metabolic steps. C4 plants use two different types of cells, mesophyll and bundle sheath, to separate initial carbon capture from the Calvin cycle. In contrast, CAM plants perform both steps in the same cell but at different times, capturing carbon at night and performing the Calvin cycle during the day.

288. (C) NADH or FADH2 to O_2
Oxidative phosphorylation is the final and most productive stage of cellular respiration. It involves the transfer of high-energy electrons from carriers like NADH and FADH2 through a series of proteins in the inner mitochondrial membrane. The final destination for these electrons is oxygen, which combines with protons to form water. This electron flow powers the synthesis of ATP, providing the cell with its primary source of energy for metabolic work.

289. (A) Tryptophan; Methionine
Plant hormones are synthesized from various building blocks provided by primary metabolism. Auxin, the hormone responsible

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256. (B) Reduces photorespiration by concentrating CO_2 around RuBisCO.
C4 plants have evolved a specialized mechanism to overcome the limitations of the enzyme RuBisCO. By using PEP carboxylase to initially capture carbon and then concentrating that carbon as carbon dioxide in specialized bundle sheath cells, these plants ensure that RuBisCO is constantly surrounded by high levels of carbon. This significantly reduces the chances of RuBisCO reacting with oxygen, thereby minimizing the wasteful process of photorespiration and increasing overall carbon fixation efficiency.

257. (C) 30-32 ATP
The complete aerobic respiration of a single glucose molecule involves glycolysis, the citric acid cycle, and oxidative phosphorylation. While the exact number can vary depending on the efficiency of the transport systems and the specific cell type, the typical net yield is between thirty and thirty-two ATP molecules. The majority of this energy is produced during the final stage in the mitochondria, where the electron transport chain powers the synthesis of ATP.

258. (A) Both A and R are true and R is the correct explanation of A.
Cytokinins are potent plant hormones that play a significant role in delaying the onset of senescence in leaves. They achieve this by stimulating the continued synthesis of proteins and chlorophyll and by promoting the movement of nutrients from other parts of the plant into the cytokinin-treated leaf. This creates a physiological "sink" that keeps the tissue healthy and active, effectively counteracting the hormonal and genetic signals that normally trigger aging and decay.

259. (B) Long-day plants
Flowering in many plants is determined by the length of the continuous dark period. A plant that flowers when the night is shorter than nine hours is effectively requiring more light and less darkness than a certain critical threshold. This behavior is characteristic of long-day plants, which typically flower in late spring or summer when the days are long and the nights are short. These species are adapted to reproductive success during these specific seasonal photoperiods.

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260. (B) Rapid, programmed cell death localized around the infection site.
The hypersensitive response is an immediate and effective defense strategy used by plants to halt the progress of an invading pathogen. Upon recognizing the threat, the plant triggers a localized burst of reactive oxygen species that leads to the rapid death of cells at the site of infection. This creates a ring of dead tissue that deprives the pathogen of nutrients and prevents it from spreading further into healthy parts of the plant.

261. (A) I only
Enzymes are biological catalysts that speed up biochemical reactions without being consumed in the process. While they are highly efficient, their activity is extremely sensitive to environmental conditions such as temperature and pH. Each enzyme has an optimal range where it functions best; beyond these limits, it may become denatured and lose its activity. Therefore, the statement claiming that enzyme activity is independent of these factors is scientifically incorrect and misleading.

262. (C) Linear sequence of amino acids.
The primary structure of a protein is its most basic level of organization, consisting of the specific, linear order of amino acids in the polypeptide chain. This sequence is determined by the genetic code within the cell's DNA. The primary structure is held together by strong covalent peptide bonds and is the fundamental template that dictates how the protein will eventually fold into its more complex secondary, tertiary, and quaternary forms.

263. (B) Shikic acid pathway
Tannins are a class of complex phenolic secondary metabolites that plants produce for protection against herbivores and pathogens. Their biosynthesis, like that of many other aromatic compounds, begins with the shikic acid pathway. This pathway produces the essential aromatic amino acid precursors that are subsequently modified through the phenylpropanoid and specialized tannin pathways. Tannins are well-known for their ability to bind and precipitate proteins, making them effective feeding deterrents.

264. (B) Apoplast pathway
The apoplast pathway is one of the major routes for the movement of water and solutes through plant tissues. It involves the continuous network of non-living components, including the porous cell walls and the spaces between cells. Water moves through this pathway relatively easily due to the lack of membrane barriers. However, this movement is eventually halted at the endodermis by the Casparian strip, which forces water to enter the living symplast.

265. (A) Both Statement I and Statement II are true.
Symplastic phloem loading involves the movement of sugars from the photosynthesizing mesophyll cells into the sieve-tube elements through plasmodesmata. This process is generally considered to be passive, meaning it does not require the direct expenditure of ATP by the plant to move the sugars. Instead, it relies on the natural concentration gradients and the high density of plasmodesmata in certain species to facilitate the translocation of nutrients toward the sink.

266. (A) Potassium and Calcium
Macronutrients are essential mineral elements that plants require in relatively large quantities for their growth and development. Potassium is vital for osmotic regulation and enzyme activation, while calcium is a key component of cell walls and acts as a signaling molecule. Other elements like iron, zinc, and boron are classified as micronutrients because they are only needed in very small, trace amounts to maintain healthy physiological functions in the plant.

267. (A) H_2O; NADP+
Non-cyclic photophosphorylation is the standard path of electron flow in photosynthesis. It begins with the extraction of electrons from water molecules during photolysis, which also releases oxygen. These electrons are then energized by light in two photosystems and passed through an electron transport chain. The final destination for these high-energy electrons is the molecule NADP+, which is reduced to NADPH, providing the reducing power needed for the Calvin cycle.

268. (C) RuBP
Ribulose-1,5-bisphosphate is a five-carbon sugar that acts as the initial acceptor of carbon dioxide in the Calvin cycle. After the cycle goes through its stages of carbon fixation and reduction to produce sugars, a series of complex reactions must take place to regenerate RuBP. This regeneration is essential to ensure that the cycle can continue to operate and fix more carbon dioxide, making RuBP both the starting reactant and the final regenerated product.

269. (B) Generate reducing power (NADH and FADH2) from the oxidation of acetyl-CoA.
The Krebs cycle is a central metabolic pathway that completes the breakdown of organic molecules within the mitochondria. While it produces a small amount of ATP directly, its most important role is to strip high-energy electrons from acetyl-CoA and transfer them to the carriers NAD+ and FAD. The resulting NADH and FADH2 then carry these electrons to the electron transport chain, where they drive the production of the majority of cellular ATP.

270. (A) ethylene/ABA; auxin
Abscission is the controlled shedding of plant organs like leaves and fruits. This process is regulated by a delicate balance between several hormones. Ethylene and abscisic acid generally promote the formation of the abscission layer at the base of the organ. Conversely, auxin produced by the healthy organ inhibits this process. When the levels of ethylene and ABA rise relative to auxin, the abscission layer matures, leading to the eventual detachment of the organ.

271. (A) Prolonged cold.
Vernalization is a physiological requirement found in many plant species where flowering is specifically induced by a sustained period of low temperature. This mechanism prevents plants from flowering prematurely during a brief warm spell in winter. Instead, it ensures that they only begin reproductive development after they have survived the full winter, guaranteeing that flowering and seed production occur during the favorable conditions of spring and summer.

272. (A) The dissipation of excess energy as heat via the xanthophyll cycle.
When light intensity is so high that it exceeds the capacity of a plant to use it for photosynthesis, the excess energy can lead to the formation of damaging reactive oxygen species. To prevent

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this, plants activate the xanthophyll cycle, a photoprotective mechanism that converts specialized pigments into a form that can safely dissipate the extra excitation energy as heat. This process helps to preserve the integrity of the photosynthetic machinery under stressful light conditions.

273. (B) Rate of enzyme-catalyzed reactions and how it changes in response to experimental parameters.
Enzyme kinetics is the branch of biochemistry that focuses on studying the speeds at which enzymes catalyze chemical reactions. By measuring how the reaction rate varies with factors like substrate concentration, temperature, and pH, scientists can determine key parameters such as Vmax and Km. This information is essential for understanding how enzymes function, how they are regulated within the cell, and how they interact with potential inhibitors or activators.

274. (D) Glucose
A polymer is a large molecule made up of many repeating smaller units called monomers. Starch is a polymer of glucose, DNA is a polymer of nucleotides, and proteins are polymers of amino acids. Glucose itself is a monosaccharide, a single sugar unit that serves as a building block for larger carbohydrates. Because it consists of only one unit, glucose is not a polymer but rather a fundamental monomer in biological systems.

275. (B) Containing at least one nitrogen atom, often in a heterocyclic ring.
Alkaloids are a large and diverse group of secondary metabolites that are primarily defined by the presence of nitrogen in their chemical structure. This nitrogen is usually part of a ring system. Alkaloids like caffeine, nicotine, and morphine are produced by plants as defensive compounds against herbivores. They are often characterized by their bitter taste and their ability to produce significant physiological and pharmacological effects in animals and humans.

276. (C) Plasmodesmata.
The symplastic pathway describes the movement of water and small solutes through the living interior of plant tissues. This is made possible by plasmodesmata, which are microscopic channels that connect the cytoplasm of adjacent cells. By moving through these channels, substances can travel from cell to cell without having to cross the plasma membrane multiple times, creating a continuous and highly regulated system for the distribution of nutrients throughout the plant.

277. (A) Zero or slightly negative
Pressure potential, also known as turgor pressure, is the physical pressure exerted by the cell contents against the cell wall. In a fully turgid cell, this pressure is positive. However, when a cell is plasmolysed, it has lost so much water that the protoplast has pulled away from the wall. In this state, there is no outward pressure being exerted, so the pressure potential drops to zero or may even become slightly negative.

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278. (D) Bundle sheath cells
C4 plants are characterized by a specialized internal structure called Kranz anatomy, which spatially separates the stages of photosynthesis. The enzyme RuBisCO is specifically sequestered within the chloroplasts of the bundle sheath cells. These cells are surrounded by mesophyll cells that actively pump carbon dioxide into them. By concentrating carbon dioxide in the bundle sheath, the plant ensures that RuBisCO functions efficiently while minimizing the wasteful effects of photorespiration.

279. (C) The Citric Acid Cycle
The mitochondrial matrix is the innermost compartment of the mitochondrion and is the site of several key metabolic processes. Most notably, it contains the enzymes and intermediates required for the citric acid cycle. This cycle completes the oxidation of fuel molecules and generates high-energy electron carriers. Other processes like glycolysis occur in the cytosol, while the light reactions and the Calvin cycle are specific to different parts of the chloroplast.

280. (A) It is reset each day by an environmental cue, such as light.
Entrainment is the mechanism that keeps a plant's internal biological clock synchronized with the natural 24-hour cycle of the environment. While the clock is endogenous and can run on its own, it would eventually drift out of sync without external input. Environmental cues, primarily the transition between light and dark at dawn and dusk, act as signals that reset the clock

its initial emergence and protects the delicate apical meristem.

248. (B) Phototropin
Phototropins are a class of blue-light sensitive protein kinases that play a central role in several light-dependent plant behaviors. They are the primary receptors responsible for phototropism, allowing plants to grow toward a light source. Additionally, phototropins mediate the movement of chloroplasts to optimize light absorption and trigger the opening of stomata to regulate gas exchange. These receptors are essential for maximizing the plant's ability to capture energy and maintain photosynthesis.

249. (C) Abscisic acid (ABA)
Abscisic acid is a vital hormone that coordinates a plant's response to various environmental stresses, particularly drought. When soil moisture is low, plants increase their synthesis of ABA in both the roots and leaves. This hormone travels to the guard cells and triggers a rapid efflux of ions, which leads to a loss of turgor and the subsequent closure of stomata. This response is critical for minimizing water loss and ensuring survival.

250. (B) It decreases Vmax but does not affect Km.
A non-competitive inhibitor reduces the overall rate of an enzyme-catalyzed reaction by binding to a site other than the active site. This binding changes the enzyme's shape, making it less effective at catalyzing the reaction regardless of how much substrate is present. As a result, the maximum velocity of the reaction is decreased. However, because the inhibitor does not interfere with the initial binding of the substrate, the Michaelis constant remains unchanged.

251. (C) A messenger RNA (mRNA) molecule
Nucleotides are the fundamental building blocks of nucleic acids like DNA and RNA. A messenger RNA molecule is a long, single-stranded polymer composed of these nucleotides, each containing a sugar, a phosphate group, and a nitrogenous base. mRNA plays a critical role in the cell by carrying the genetic code from the DNA in the nucleus to the ribosomes, where it serves as the template for building specific proteins during the process of translation.

252. (B) Defensive
Terpenes and phenolic compounds are among the most important classes of secondary metabolites involved in plant defense. These molecules often function as toxins, feeding deterrents, or antimicrobial agents that protect the plant from being eaten by herbivores or infected by pathogens. While some have other roles, their presence in various tissues is primarily an evolutionary adaptation that enhances the plant's ability to survive and reproduce in a hostile environmental landscape.

253. (C) Water moves from a region of lower water potential to a region of higher water potential.
Water potential is a measure of the free energy of water, and its direction of movement is always governed by thermodynamics. Water spontaneously flows from a region where the water potential is higher to a region where it is lower. Pure water at standard pressure is assigned a value of zero, and the addition of solutes always makes the potential more negative, effectively lowering it and creating the gradient for water uptake.

254. (D) It is a passive process that does not require energy.
Active transport is an essential biological process that allows cells to move molecules across membranes against their natural concentration gradient. This requires the direct use of metabolic energy, which is usually provided by the hydrolysis of ATP. Specialized protein carriers or pumps are also necessary to facilitate this movement. Because it is powered by cellular energy to overcome entropy, active transport is considered a highly regulated, non-passive process.

255. (B) To transfer electrons from Photosystem II to Photosystem I and pump protons.
The cytochrome b6f complex is an integral membrane protein that serves as a critical link between the two photosystems in the thylakoid. As electrons move from photosystem II through this complex, it uses some of their energy to pump protons from the stroma into the thylakoid lumen. This activity is essential for establishing the proton gradient that eventually powers ATP synthesis, while also ensuring the continued flow of electrons toward photosystem I.

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for cell elongation and apical dominance, is primarily derived from the aromatic amino acid tryptophan. Ethylene, the gaseous hormone that triggers fruit ripening and leaf abscission, is synthesized from the amino acid methionine. These specific biosynthetic origins are essential for understanding how plants regulate their growth and development through hormonal signaling.

290. (A) P-3, Q-2, R-4, S-1
Phytochrome A is responsible for mediating responses to far-red light, which is important for shade avoidance. Phototropin 1 is the primary receptor for blue-light induced phototropism. Cryptochrome 1 helps mediate the inhibition of hypocotyl elongation under blue light conditions. Phytochrome B is the main receptor for red-light induced processes, such as the promotion of seed germination and the control of flowering in many species.

291. (A) Salicylic acid
Systemic acquired resistance is a defense mechanism that provides broad-spectrum immunity to the entire plant following a localized pathogen attack. Salicylic acid serves as a crucial signaling molecule in this process, helping to activate defense genes in distant tissues. This systemic response allows the plant to remain protected against subsequent infections by various pathogens over an extended period, significantly increasing its chances of survival and healthy growth in nature.

292. (C) An apoenzyme plus its cofactor/coenzyme.
A holoenzyme represents the fully functional, catalytically active form of an enzyme. Many enzymes are composed of a protein part, called an apoenzyme, which is inactive on its own. To perform its function, the apoenzyme must be bound to a non-protein component known as a cofactor or a coenzyme. The complete assembly of both the protein and its required cofactor is what constitutes the holoenzyme and enables chemical catalysis.

293. (A) Phospholipids
Amphipathic molecules are those that contain both a hydrophilic, water-loving region and a hydrophobic, water-fearing region. Phospholipids are the classic example of such molecules in biology. They possess a polar phosphate head and two non-polar fatty acid tails. This unique property is what allows them to spontaneously form stable bilayers in water, creating the fundamental structure of all cell membranes and providing a selective barrier between different cellular compartments.

294. (A) Secondary metabolites
Secondary metabolites are a diverse group of compounds that plants produce for specialized functions rather than basic cellular survival. These include terpenes for scent and defense, phenolic compounds for structure and protection, and nitrogenous compounds like alkaloids for deterring herbivores. While not essential for primary growth, these molecules are critical for a plant's ability to interact with its environment, defend itself, and attract pollinators, thus enhancing its overall ecological fitness.

295. (A) High internal CO_2 concentration
Stomatal movement is regulated by several environmental cues to balance the needs for gas exchange and water conservation. When the internal concentration of carbon dioxide in the leaf becomes high, it signals that the plant has enough carbon for photosynthesis. This triggers the closure of the stomata to prevent unnecessary water loss. Other factors like light and low carbon dioxide typically promote stomatal opening to facilitate further carbon capture.

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296. (A) During the night
CAM plants have evolved a specialized photosynthetic strategy to conserve water in arid environments. They open their stomata and perform the initial carboxylation reaction only during the night, when temperatures are lower and humidity is higher. During this time, carbon dioxide is captured by PEP carboxylase and stored as malic acid. During the following day, the stomata close, and the stored carbon is released for use in the Calvin cycle.

297. (A) Both Statement I and Statement II are true.
Glycolysis is a universal metabolic pathway that can operate whether or not oxygen is present, providing a basic level of energy in both aerobic and anaerobic conditions. However, the subsequent stages of cellular respiration, including the citric acid cycle and oxidative

phosphorylation, are strictly aerobic. They require oxygen as the final electron acceptor in the transport chain to continue functioning and to produce a significantly higher yield of ATP for the cell.

298. (D) Gibberellin
Bolting is a rapid burst of stem growth and the subsequent development of flowers, which typically occurs in response to environmental cues like day length or cold. In many rosette-forming plants, this process is controlled by gibberellins. If exogenous gibberellins are applied to these plants, they can be induced to bolt even without the normal environmental triggers. This demonstrates the powerful role of gibberellins in regulating stem elongation and the transition to reproductive growth.

299. (A) Both A and R are true and R is the correct explanation of A.
Phytochromes allow plants to perceive the quality of light in their environment by monitoring the ratio of red to far-red wavelengths. In full sun, red light is abundant, keeping phytochrome in its active Pfr form. However, under a leaf canopy, the red light is absorbed by other plants, leaving an environment enriched in far-red light. This far-red light converts Pfr to the inactive Pr form, which triggers shade avoidance responses, such as rapid stem elongation.

300. (A) Vitamins are organic molecules, while minerals are inorganic elements.
The primary distinction between vitamins and minerals lies in their chemical composition. Vitamins are organic compounds that plants can often synthesize themselves to function as cofactors for various enzymes. In contrast, minerals are inorganic elements that plants must absorb from the soil. Both are essential in small quantities for maintaining the metabolic health and growth of the plant, but they differ fundamentally in their origins and their basic chemical nature.

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CHAPTER 06
Plant Ecology

1. Which of the following best defines a plant community?
(A) Specific collection of individuals of the same plant species within a defined area.
(B) Assemblage of different plant populations occurring together in a specific area.
(C) Total set of living organisms, including plants, animals, and microbes, in an ecosystem.
(D) Sum of physical and chemical factors influencing various forms of plant life in a habitat.

2. Which statement correctly describes a key attribute of community structure?
(A) It includes aspects like species richness, stratification, and species dominance.
(B) All species within a community possess identical population sizes and growth rates.
(C) Community structure is entirely static and does not change significantly over time.
(D) The physical environment is not formally considered a part of community structure.

3. The number of species per unit area is referred to as:
(A) Species evenness
(B) Species dominance
(C) Species richness
(D) Species frequency

4. Which measurement of species diversity considers both the number of species and their relative abundance?
(A) Alpha diversity
(B) Gamma diversity
(C) Species count
(D) Simpson's Index

5. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): Species diversity is generally higher in tropical regions compared to temperate regions.
Reason (R): Tropical regions have experienced a longer period of evolutionary stability and receive higher solar energy, supporting greater productivity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

6. A botanist studies the variety of plant species in a single, small forest patch. What level of species diversity is being measured?
(A) Gamma diversity
(B) Alpha diversity
(C) Beta diversity
(D) Ecosystem diversity

7. All of the following are considered attributes of a community EXCEPT:
(A) Stratification
(B) Dominance
(C) Species diversity
(D) Natality

8. Match the ecological terms in List I with their descriptions in List II.
List I: (Ecological Term)
P. Ecotype
Q. Ecocline
R. Ecade (Ecads)
S. Ecotone
List II: (Description)
1. A transitional zone between two different communities.
2. A genetically distinct population adapted to specific environmental conditions.
3. A population with environmentally induced variations that are not heritable.
4. A gradual change in species composition along an environmental gradient.

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28. Which of the following is a primary consumer in a terrestrial food chain?
(A) Lion
(B) Grasshopper
(C) Snake
(D) Hawk

29. The rate at which radiant energy is converted by producers into organic substances is known as:
(A) Net primary productivity
(B) Secondary productivity
(C) Gross primary productivity
(D) Community productivity

30. Consider the following statements regarding the carbon cycle:
1. Photosynthesis removes carbon from the atmosphere.
2. Respiration by plants and animals returns carbon to the atmosphere.
3. The burning of fossil fuels has no significant impact on the atmospheric carbon pool.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

31. The process of breakdown of complex organic matter into simpler inorganic substances like CO_2, water, and nutrients is called:
(A) Decomposition
(B) Productivity
(C) Mineralization
(D) Stratification

32. In the phosphorus cycle, which of the following is the major reservoir of phosphorus?
(A) Atmosphere
(B) Rocks and sediments
(C) Oceans
(D) Living organisms

33. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): The pyramid of energy in any ecosystem is always upright.
Reason (R): According to the 10% law, only about 10% of the energy is transferred from one trophic level to the next, with the rest being lost as heat.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

34. Which of the following is a characteristic feature of Indian grassland ecosystems?
(A) Subject to periodic fires and grazing.
(B) Dominated by large coniferous trees.
(C) High annual rainfall exceeding 2000 mm.
(D) Found primarily in high-altitude Himalayan regions.

35. Estuaries are considered highly productive ecosystems. Which of the following is the most appropriate reason for this?
(A) They are deep water bodies with no light penetration.
(B) They have very stable salinity and temperature.
(C) They receive high nutrient influx from both rivers and the sea.
(D) They are completely free from any type of predators.

36. An interaction between two species where both are harmed is known as:
(A) Commensalism
(B) Amensalism
(C) Predation
(D) Competition

37. The relationship between a fungus and algae in a lichen, where both organisms benefit, is an example of:
(A) Parasitism
(B) Competition
(C) Symbiosis (Mutualism)
(D) Predation

38. Which of the following defines 'herbivory'?
(A) An interaction where one organism kills and consumes another.
(B) An interaction where an organism feeds on plants.
(C) An interaction where two organisms vie for the same limited resources.
(D) An interaction where one organism benefits

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their competitive ability near the carrying capacity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

19. Which of the following is a typical characteristic of an 'r-selected' species?
(A) Long lifespan
(B) Large body size
(C) Production of a large number of offspring
(D) High parental care

20. Arrange the following stages of a typical primary succession on land (xerosere) in the correct chronological order:
1. Shrub stage
2. Moss stage
3. Forest stage
4. Lichen stage
5. Herb stage

(A) 4, 2, 5, 1, 3
(B) 2, 4, 1, 5, 3
(C) 4, 5, 2, 1, 3
(D) 1, 2, 4, 5, 3

21. What does the term 'population regulation' primarily refer to?
(A) The geographical distribution of a population.
(B) The ratio of males to females in a population.
(C) Factors determining carrying capacity and preventing indefinite growth.
(D) The pattern of spacing of individuals within a population.

22. The term 'trophic level' in an ecosystem refers to:
(A) The geographical area occupied by an organism.
(B) The position an organism occupies in a food chain.
(C) The amount of biomass in a given area.
(D) The rate of energy production.

23. Which of the following is an example of a biotic component of an ecosystem?
(A) Sunlight
(B) Soil pH
(C) Water
(D) Decomposers

24. A food web is considered a more realistic representation of trophic relationships than a food chain because:
(A) It shows organisms in multiple food chains feeding at various trophic levels.
(B) It primarily focuses on interactions between primary producers and consumers.
(C) It demonstrates that most organisms feed exclusively on one type of food.
(D) It illustrates a single, linear flow of energy through specific organisms.

25. Match the ecological pyramids in List I with their characteristics in List II.
List I: (Ecological Pyramid)
P. Pyramid of Numbers
Q. Pyramid of Biomass
R. Pyramid of Energy
S. Inverted Pyramid of Biomass
List II: (Characteristic)
1. Always upright as energy is lost at each successive trophic level.
2. Represents the total number of individuals at each trophic level.
3. Can be observed in a pond ecosystem where phytoplankton are producers.
4. Represents the total dry weight of organisms at each trophic level.

(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-2, R-3, S-1
(D) P-2, Q-1, R-4, S-3

26. What is the primary source of energy for most ecosystems on Earth?
(A) Solar radiation
(B) Geothermal heat
(C) Chemical energy from inorganic compounds
(D) Decomposing organic matter

27. The process by which bacteria convert atmospheric nitrogen (N2) into ammonia (NH3) is called:
(A) Nitrification
(B) Denitrification
(C) Ammonification
(D) Nitrogen fixation

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(D) Soil color is not related to its composition or fertility.

92. The layer of soil that is richest in organic matter (humus) is the:
(A) B horizon (Subsoil)
(B) A horizon (Topsoil)
(C) C horizon (Parent material)
(D) R horizon (Bedrock)

93. The phenomenon of global warming is primarily caused by an increase in the atmospheric concentration of:
(A) Ozone (O3)
(B) Sulfur dioxide (SO_2)
(C) Greenhouse gases like CO_2 and CH_4
(D) Chlorofluorocarbons (CFCs)

94. Lichens are often used as bio-indicators for:
(A) Water pollution
(B) Soil salinity
(C) Heavy metal contamination in water
(D) Air pollution, particularly SO_2 levels

95. One of the main objectives of the Environmental Protection Act, 1986, is to:
(A) Provide a framework for the coordination of central and state authorities in environmental protection.
(B) Exclusively manage forest resources for timber production.
(C) Promote the use of plastic and non-biodegradable materials.
(D) Fund international research on climate change without domestic action.

96. Which of the following is NOT a level of biodiversity?
(A) Genetic diversity
(B) Trophic diversity
(C) Species diversity
(D) Ecosystem diversity

97. The concept of biodiversity 'hotspots' was developed by:
(A) E.O. Wilson
(B) Norman Myers
(C) A.G. Tansley
(D) Rachel Carson

98. An example of a management approach for biodiversity that focuses on a specific species to garner conservation support is the:
(A) Flagship species approach
(B) Ecosystem approach
(C) Hotspot approach
(D) Bioregional approach

99. Which of the following best describes 'Beta diversity'?
(A) The diversity of species within a single community.
(B) The total diversity of species across all habitats in a large region.
(C) Rate of change in species composition between communities along a gradient.
(D) The genetic diversity within a single species.

100. Plants that are adapted to grow in saline environments are called:
(A) Hydrophytes
(B) Xerophytes
(C) Mesophytes
(D) Halophytes

101. The final, stable community in an ecological succession is known as the climax. The theory that a region can have multiple, stable climax communities depending on local environmental factors is the:
(A) Monoclimax theory
(B) Climax-pattern hypothesis
(C) Polyclimax theory
(D) Cyclic climax theory

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102. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): In an ecotone, species diversity is often higher than in the adjacent communities.
Reason (R): The ecotone contains species from both adjoining communities as well as species uniquely adapted to the transitional zone, a phenomenon known as the edge effect.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

and the other is unaffected.

39. The transfer of pollen from the anther to the stigma of a flower is termed:
(A) Fertilization
(B) Germination
(C) Dispersal
(D) Pollination

40. Which statement incorrectly describes the concept of a 'niche'?
(A) It is synonymous with the term 'habitat'.
(B) It is the physical place where an organism lives.
(C) It includes the organism's role in the ecosystem.
(D) It encompasses the range of environmental conditions an organism can tolerate.

41. The principle of competitive exclusion states that:
(A) Two species can coexist indefinitely if they use the same limited resource.
(B) Competition leads to an increase in the population of both competing species.
(C) Two species competing for the same limiting resource cannot coexist at constant population values.
(D) One species will always help another species to survive.

42. Match the types of interaction in List I with their effects on Species A and B in List II.
List I: (Type of Interaction)
P. Mutualism
Q. Competition
R. Predation
S. Commensalism
List II: (Effect on Species A and B)
1. Species A (+), Species B (0)
2. Species A (+), Species B (+)
3. Species A (-), Species B (-)
4. Species A (+), Species B (-)
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-3, S-1
(D) P-3, Q-2, R-1, S-4

43. 'Resource partitioning' is an ecological process that allows:
(A) One species to completely eliminate another species from a habitat.
(B) A single species to monopolize all available resources.
(C) The accumulation of resources by a dominant species.
(D) Competing species to share resources by using them differently.

44. When two competing species evolve different characteristics to reduce competition, it is known as:
(A) Niche overlap
(B) Character displacement
(C) Resource partitioning
(D) Competitive exclusion

45. The physical environment of an organism includes all of the following except:
(A) Temperature
(B) Soil composition
(C) Predation
(D) Sunlight

46. Which of the following is considered part of the biotic environment?
(A) Annual rainfall
(B) Soil texture
(C) Atmospheric pressure
(D) Symbiotic fungi

47. Which major terrestrial biome is characterized by permafrost, low-growing vegetation like mosses, lichens, and dwarf shrubs, and extremely cold temperatures?
(A) Tundra
(B) Tropical Rainforest
(C) Temperate Grassland
(D) Desert

48. In the context of phytogeographical regions, the Western Ghats are known for their:
(A) Alpine vegetation
(B) High endemism and tropical evergreen forests
(C) Mangrove forests
(D) Extensive temperate grasslands

49. Which of the following is NOT a major forest type found in Madhya Pradesh?
(A) Tropical Moist Deciduous Forest
(B) Alpine Forest

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(A) P-2, Q-4, R-3, S-1
(B) P-3, Q-1, R-2, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-1, Q-4, R-3, S-2

9. The development of succulent stems in desert plants is an example of which type of ecological adaptation?
(A) Physiological adaptation
(B) Anatomical adaptation
(C) Morphological adaptation
(D) Behavioral adaptation

10. Which of the following is an incorrect statement regarding plant adaptations to water scarcity?
(A) Increased number of stomata on the upper leaf surface to maximize gas exchange.
(B) Development of a deep taproot system to access groundwater.
(C) Presence of a thick waxy cuticle on the epidermis to reduce transpiration.
(D) Modification of leaves into spines to reduce water loss.

11. What is the primary physiological adaptation of CAM (Crassulacean Acid Metabolism) plants to arid environments?
(A) They have highly efficient C4 photosynthesis to reduce photorespiration.
(B) They shed their leaves during the dry season to conserve water.
(C) They store large amounts of water in their leaves and stems.
(D) They close their stomata during the day and open them at night to fix CO_2.

12. Consider the following statements about ecological succession:
1. It is an orderly and directional process of community change.
2. It always culminates in a stable climax community.
3. It can be initiated on a barren rock (primary) or in an area where an existing community has been removed (secondary).

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

13. The first group of organisms to colonize a barren area during primary succession is known as:
(A) Climax species
(B) Seral community
(C) Pioneer species
(D) Ecotonal species

14. The concept of climax in ecological succession refers to:
(A) The initial stage of colonization.
(B) A community that is in a state of continuous, rapid change.
(C) Any intermediate stage (seral stage) in the successional process.
(D) A relatively stable community in equilibrium with its environment.

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15. What is an 'Ecade' or 'Ecophene'?
(A) Non-heritable phenotypic variations in a plant species caused by the environment.
(B) A genetically fixed variant within a species suited to a particular habitat.
(C) A transitional zone between two distinct ecological communities.
(D) A community at the final stage of succession.

16. Which of the following is a characteristic of a population, but not of an individual organism?
(A) Life span
(B) Birth rate
(C) Metabolism
(D) Growth

17. The S-shaped or logistic growth curve of a population is characterized by:
(A) Unlimited growth without any environmental resistance.
(B) Initial slow growth, then rapid growth, then slowing at carrying capacity.
(C) A phase of rapid growth followed by a decline to zero.
(D) A constant growth rate indefinitely.

18. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): Species with a 'k-selection' life history strategy are typically found in stable, predictable environments.
Reason (R): k-selected species invest heavily in a few, high-quality offspring, which increases

(D) Soil profile

60. Match the soil horizons in List I with their descriptions in List II.
List I: (Soil Horizon)
P. O Horizon
Q. A Horizon
R. B Horizon
S. C Horizon
List II: (Description)
1. Zone of accumulation (illuviation), subsoil.
2. Topsoil, rich in humus and minerals.
3. Partially weathered parent material.
4. Surface layer of fresh and decomposing organic matter.
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-2, R-1, S-4

61. Which of the following is NOT a major factor in soil formation?
(A) Climate
(B) Parent material
(C) Atmospheric pressure
(D) Topography

62. The main components of soil are:
(A) Sand, silt, and clay only.
(B) Rocks, pebbles, and gravel only.
(C) Nitrogen, phosphorus, and potassium only.
(D) Minerals, organic matter, water, and air.

63. The release of substances like sulfur dioxide (SO_2) and nitrogen oxides (NOx) into the atmosphere is the primary cause of:
(A) Acid rain
(B) Ozone layer depletion
(C) Global warming
(D) Eutrophication

64. The 'greenhouse effect' is the process by which:
(A) UV radiation is blocked by the ozone layer.
(B) Certain atmospheric gases trap outgoing infrared radiation, warming the Earth's surface.
(C) Plants release oxygen during photosynthesis.
(D) Acidic pollutants are deposited on the Earth's surface.

65. Arrange the following events related to environmental protection in India in chronological order of their enactment/launch:
1. The Water (Prevention and Control of Pollution) Act
2. The Environment (Protection) Act
3. Project Tiger
4. The Air (Prevention and Control of Pollution) Act
(A) 3, 1, 4, 2
(B) 1, 3, 4, 2
(C) 3, 4, 1, 2
(D) 2, 1, 4, 3

66. The primary pollutants responsible for the depletion of the stratospheric ozone layer are:
(A) Chlorofluorocarbons (CFCs)
(B) Carbon dioxide and methane
(C) Sulfur dioxide and nitrogen oxides
(D) Particulate matter and smoke

67. What is a 'plant indicator'?
(A) A plant that is genetically modified to show a specific color.
(B) A device used to measure plant growth.
(C) A plant species or community that indicates the status of specific environmental conditions.
(D) A chart indicating the flowering season of various plants.

68. The Environment (Protection) Act was enacted in India in which year?
(A) 1972
(B) 1981
(C) 1992
(D) 1986

69. Which of the following is an example of a secondary air pollutant?
(A) Carbon monoxide (CO)
(B) Sulfur dioxide (SO_2)
(C) Ground-level ozone (O_3)
(D) Particulate matter

70. The term 'biodiversity' refers to:
(A) The number of individuals of a particular species.
(B) The variety of life on Earth at all its levels, from genes to ecosystems.
(C) The total biomass of producers in an

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(C) Tropical Dry Deciduous Forest
(D) Tropical Thorn Forest

50. The core principle of conservation biology is to:
(A) Preserve biodiversity at all levels, from genes to ecosystems.
(B) Promote the introduction of exotic species for economic benefit.
(C) Focus exclusively on the conservation of economically important species.
(D) Maximize the immediate extraction of natural resources.

51. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): In-situ conservation involves protecting species within their natural habitats.
Reason (R): Establishing National Parks and Wildlife Sanctuaries is a primary strategy for in-situ conservation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

52. What is watershed management?
(A) Construction of large dams for hydroelectric power generation only.
(B) Management of a single water body like a lake or a pond.
(C) Process of diverting river water for industrial use.
(D) Integrated management of land, water, and vegetation resources.

53. The primary difference between a National Park and a Wildlife Sanctuary in India is that:
(A) No human activity is allowed in a Sanctuary, while it is permitted in a National Park.
(B) National Parks are meant for conserving only plants, while Sanctuaries are for animals.
(C) National Parks have higher protection and most human activities are prohibited.
(D) Sanctuaries are managed by the central government, while National Parks are state-run.

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54. A Biosphere Reserve is a unique concept that aims to:
(A) Conserve wildlife for recreational hunting.
(B) Reconcile biodiversity conservation with sustainable human development.
(C) Exclusively protect a single flagship species like the tiger or elephant.
(D) Serve as a large-scale commercial forestry plantation.

55. Consider the following statements about soil conservation:
1. Terracing on hill slopes helps to reduce soil erosion by water.
2. Afforestation increases soil erosion by loosening the topsoil.
3. Overgrazing by livestock can lead to significant soil degradation and erosion.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

56. The texture of a soil is determined by the relative proportions of:
(A) Sand, silt, and clay
(B) Water, air, and organic matter
(C) Humus, minerals, and nutrients
(D) Nitrogen, phosphorus, and potassium

57. Which soil property refers to its ability to hold positively charged ions (cations) like Ca2+, K^+, and Mg2+?
(A) Soil pH
(B) Soil structure
(C) Cation Exchange Capacity (CEC)
(D) Bulk density

58. The process of soil formation is known as:
(A) Pedogenesis
(B) Petrification
(C) Metamorphosis
(D) Succession

59. A vertical section of soil from the ground surface downwards to where the soil meets the underlying rock is called a:
(A) Soil horizon
(B) Soil texture
(C) Soil aggregate

benefited.
3. In amensalism, one species is harmed while the other is unaffected.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

81. Which of the following is NOT a function of an ecosystem?
(A) Productivity
(B) Population regulation
(C) Decomposition
(D) Energy flow

82. In an upright pyramid of biomass in a terrestrial ecosystem, which trophic level would have the maximum biomass?
(A) Primary producers
(B) Primary consumers
(C) Secondary consumers
(D) Tertiary consumers

83. The conversion of nitrate (NO3-) back into gaseous nitrogen (N2) by bacteria, returning it to the atmosphere, is called:
(A) Nitrogen fixation
(B) Nitrification
(C) Denitrification
(D) Ammonification

84. Net Primary Productivity (NPP) is calculated as:
(A) GPP + Respiration (R)
(B) GPP / Respiration (R)
(C) Respiration (R) - GPP
(D) GPP - Respiration (R)

85. Which of the following ecosystems is characterized by species like Rhizophora and Avicennia, adapted to saline, waterlogged soil?
(A) Alpine meadows
(B) Tropical rainforests
(C) Mangrove wetlands
(D) Thar desert

86. The concept of 'niche' was first comprehensively defined by:
(A) Charles Darwin
(B) Joseph Grinnell
(C) G.F. Gause
(D) A.G. Tansley

87. Which of the following is an example of a biotic interaction?
(A) A plant's response to low temperature.
(B) A plant wilting due to lack of water.
(C) A plant growing towards a light source.
(D) A bee pollinating a flower.

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88. Match the conservation methods in List I with the examples in List II.
List I: (Conservation Method)
P. In-situ conservation
Q. Ex-situ conservation
R. Watershed Management
S. Soil Conservation
List II: (Example)
1. Botanical Garden
2. Contour ploughing
3. Biosphere Reserve
4. Check dams
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-4, S-3

89. The Deccan Peninsula is predominantly characterized by:
(A) Coniferous forests and alpine scrub.
(B) Mangrove swamps and coastal vegetation.
(C) Tropical deciduous forests and scrublands.
(D) Temperate broad-leaved forests.

90. A natural resource is defined as:
(A) Any material or substance occurring in nature which can be exploited for economic gain.
(B) Any material created by humans in a factory.
(C) Only living organisms that can be used for food.
(D) Only minerals extracted from the Earth's crust.

91. Which of the following is an incorrect statement regarding soil properties?
(A) Clay soils have small particles and high water-holding capacity.
(B) Sandy soils have large particles and low water-holding capacity.
(C) Loam soil is considered ideal for agriculture as it is a mix of sand, silt, and clay.

ecosystem.
(D) The interaction between living and non-living components.

71. Monitoring and documentation of biodiversity are crucial for:
(A) Identifying which species to exploit for commercial gain.
(B) Creating a list of pests to be eradicated.
(C) Promoting the introduction of non-native species.
(D) Understanding changes and developing conservation strategies.

72. Which of the following is considered a major driver of biodiversity change and loss?
(A) Habitat destruction and fragmentation
(B) Strict enforcement of conservation laws
(C) Establishment of protected areas
(D) Sustainable use of natural resources

73. 'Hotspots' of biodiversity are regions that:
(A) Have extremely high temperatures throughout the year.
(B) Are major centers of industrial pollution.
(C) Have high richness, high endemism, and are under threat.
(D) Are completely devoid of human populations.

74. Ex-situ conservation is a biodiversity management approach that involves:
(A) Conserving components of biodiversity outside their natural habitats, such as in zoos or seed banks.
(B) Protecting animals and plants in their natural habitat.
(C) Allowing unregulated harvesting of species.
(D) Restoring degraded ecosystems without human intervention.

75. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): The logistic growth model (S-shaped curve) is a more realistic representation of population growth in nature than the exponential model.
Reason (R): The logistic model incorporates environmental resistance and the concept of carrying capacity (K), which limits population growth.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

76. In the context of plant adaptations, sunken stomata are a feature primarily designed to:
(A) Increase the rate of photosynthesis.
(B) Reduce water loss through transpiration by humidifying a microenvironment.
(C) Enhance the absorption of mineral nutrients from the soil.
(D) Attract pollinators for cross-pollination.

77. Which statement is correct regarding changes during ecological succession?
(A) Species diversity generally decreases as succession proceeds.
(B) The total biomass of the community decreases towards the climax stage.
(C) Pioneer species are typically replaced by species that are more competitive in stable conditions.
(D) The complexity of food webs simplifies as the community matures.

78. The mechanism of succession where early colonizers modify the environment in ways that make it less suitable for themselves but more suitable for later species is called:
(A) Inhibition
(B) Tolerance
(C) Neutralism
(D) Facilitation

79. The age structure of a rapidly growing population would be best represented by a pyramid with a:
(A) Broad base and a tapering top.
(B) Narrow base and a narrow top.
(C) Uniform width from base to top.
(D) Narrow base and a broad top.

80. Consider the following statements related to species interactions:
1. In parasitism, the parasite benefits while the host is harmed.
2. In commensalism, one species benefits while the other is neither harmed nor

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103. A J-shaped growth curve is characteristic of a population:
(A) Experiencing logistic growth in a resource-limited environment.
(B) That has reached the carrying capacity of its habitat.
(C) That is declining due to environmental stress.
(D) Experiencing exponential growth with no limiting factors.

104. The carrying capacity (K) of an environment is:
(A) The maximum number of individuals of a species that an environment can sustainably support.
(B) The initial number of individuals colonizing a new habitat.
(C) The rate at which a population increases in size.
(D) The total biomass of all species in an ecosystem.

105. Organisms that feed on dead organic matter (detritus) are called:
(A) Producers
(B) Carnivores
(C) Detritivores
(D) Herbivores

106. In the context of mineral cycling, which of the following is an example of a gaseous cycle?
(A) Nitrogen cycle
(B) Phosphorus cycle
(C) Sulfur cycle
(D) Potassium cycle

107. Two species of barnacles exist on a rocky shore. Species A occupies the upper intertidal zone, while Species B occupies the lower zone. When Species B is removed, Species A spreads to the lower zone. This demonstrates that:
(A) Species A and B have a mutualistic relationship.
(B) The fundamental niche of Species A is restricted to the upper zone.
(C) Both species have identical niches.
(D) The realized niche of A was smaller than its fundamental niche due to competition.

108. Consider the following pairs related to plant adaptations:
1. Hydrophytes: Presence of aerenchyma
2. Xerophytes: Sunken stomata and thick cuticle
3. Halophytes: High osmotic pressure in cell sap

Which of the pairs given above are correctly matched?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

109. Which of the following is a physical environmental factor?
(A) Competition
(B) Parasitism
(C) Light intensity
(D) Pollination

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110. The 'Silent Valley' in Kerala is well-known for protecting:
(A) A vast grassland ecosystem from industrial development.
(B) A mangrove forest from urban expansion.
(C) A desert ecosystem from overgrazing.
(D) A pristine tropical evergreen rainforest from a hydroelectric project.

111. Which Indian state has the largest area under forest cover?
(A) Madhya Pradesh
(B) Arunachal Pradesh
(C) Chhattisgarh
(D) Maharashtra

112. The accumulation of fine soil particles and mineral salts in the B-horizon of a soil profile is a process called:
(A) Eluviation
(B) Illuviation
(C) Weathering
(D) Humification

113. 'Eutrophication' of a water body is caused by:
(A) The introduction of toxic heavy metals.
(B) Enrichment of nutrients, leading to excessive algal growth.
(C) An increase in water temperature.
(D) Acid rain deposition.

205. Two species of warblers live in the same spruce tree but feed on insects in different parts of the tree, one in the upper canopy and one in the lower branches. This is an example of:
(A) Competitive exclusion
(B) Character displacement
(C) Resource partitioning
(D) Mutualism

206. A biome with hot, dry summers and cool, moist winters, often dominated by fire-adapted shrubs is:
(A) Tropical Rainforest
(B) Tundra
(C) Boreal Forest
(D) Mediterranean (Chaparral)

207. The main purpose of soil conservation practices like contour farming and strip cropping is to:
(A) Reduce the speed of water runoff and prevent soil erosion.
(B) Increase soil fertility by adding chemicals.
(C) Remove all organic matter from the soil.
(D) Increase the slope of the land for better drainage.

208. The 'Ozone Day' is celebrated internationally on:
(A) June 5th
(B) September 16th
(C) April 22nd
(D) December 1st

209. Which of the following represents an in-situ biodiversity conservation method?
(A) Seed bank
(B) Biosphere reserve
(C) Botanical garden
(D) Zoological park

210. Consider the following statements about soil:
1. Soil porosity is the volume of pore spaces in the soil that can be filled with air or water.
2. Sandy soils have high porosity but low water retention.
3. Clay soils have low porosity but high water retention.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

211. In community ecology, 'dominance' of a species is often measured by its:
(A) Rarity and limited distribution.
(B) Ability to mimic other species.
(C) High numbers, large biomass, or significant effect on the community.
(D) Role as a pollinator.

212. Which of the following is an example of an anatomical adaptation in xerophytes?
(A) Modification of leaves into spines.
(B) Shedding of leaves during the dry season.
(C) A deep and extensive root system.
(D) Presence of multiple layers of epidermis and sunken stomata.

213. The intermediate stages of development in an ecological succession are called:
(A) Climax
(B) Pores
(C) Seres
(D) Nudation

214. Density-independent factors limiting population growth include all of the following EXCEPT:
(A) Wildfire
(B) Intraspecific competition
(C) Floods
(D) Extreme cold

215. The standing state in an ecosystem refers to the:
(A) Amount of living material (biomass) at a particular time.
(B) Rate of energy capture by producers.
(C) Total number of species in the ecosystem.
(D) Amount of inorganic nutrients present in the soil at a given time.

216. The functional role of an organism in its ecosystem is its:
(A) Niche
(B) Habitat
(C) Trophic level
(D) Community

217. The 'Chipko Movement' is associated with the conservation of:
(A) Water resources
(B) Marine life

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125. Arrange the following soil horizons in the correct sequence from top to bottom in a typical well-developed soil profile.
1. B-Horizon (Subsoil)
2. C-Horizon (Parent material)
3. A-Horizon (Topsoil)
4. O-Horizon (Organic layer)

(A) 4, 3, 1, 2
(B) 3, 4, 1, 2
(C) 4, 1, 3, 2
(D) 3, 1, 4, 2

126. A relationship where one organism lives on or inside another organism (the host), causing it harm, is:
(A) Commensalism
(B) Mutualism
(C) Amensalism
(D) Parasitism

127. Which of the following best represents a grassland type found in Madhya Pradesh?
(A) Savannah-type grasslands with scattered trees
(B) Alpine meadows
(C) Shola grasslands
(D) Coastal grasslands

128. The Chipko movement was primarily focused on:
(A) Preventing the construction of a large dam.
(B) Protecting forests from commercial logging by hugging trees.
(C) Cleaning a polluted river.
(D) Conserving a specific endangered animal species.

129. The concept of 'Biosphere Reserve' was launched by which international organization?
(A) WWF
(B) UNESCO
(C) IUCN
(D) UNEP

130. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): The phosphorus cycle is a sedimentary cycle.
Reason (R): The main reservoir of phosphorus is in rocks, and it has no significant gaseous phase in the atmosphere.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

131. Soil structure refers to:
(A) The relative proportions of sand, silt, and clay.
(B) The acidity or alkalinity of the soil.
(C) The arrangement of soil particles into aggregates.
(D) The vertical layers or horizons in the soil.

132. The phenomenon where a single gene affects multiple phenotypic traits is known as pleiotropy. In ecology, this concept helps explain:
(A) The process of ecological succession.
(B) The calculation of species diversity indices.
(C) The formation of soil horizons.
(D) Why r- and k-selection involve a suite of co-evolving traits rather than single characteristics.

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133. The increase in the concentration of a toxic substance in the tissues of organisms at successively higher levels in a food chain is known as:
(A) Eutrophication
(B) Biodegradation
(C) Biomagnification
(D) Bioremediation

134. Which plant shows morphological adaptations like pneumatophores for respiration in waterlogged soil?
(A) Cactus (Opuntia)
(B) Mangrove (Avicennia)
(C) Water hyacinth (Eichhornia)
(D) Pine (Pinus)

135. Autogenic succession is a type of succession where:
(A) The community change is brought about by external environmental factors.
(B) The succession starts on a previously uninhabited area.
(C) The succession process is arrested before reaching the climax stage.

159. The relationship between cattle egrets and grazing cattle, where the birds feed on insects flushed out by the cattle who are unaffected, is an example of:
(A) Commensalism
(B) Parasitism
(C) Mutualism
(D) Competition

160. Which of the following biomes receives the highest annual precipitation?
(A) Temperate Deciduous Forest
(B) Tropical Rainforest
(C) Tundra
(D) Desert

161. Plants adapted to dry conditions (xerophytes) often exhibit Crassulacean Acid Metabolism (CAM) primarily to:
(A) Maximize water loss through transpiration.
(B) Reduce water loss by opening stomata only at night.
(C) Increase the rate of photosynthesis during the day.
(D) Store more starch in the leaves.

162. The concept that succession proceeds towards a single, climatically determined climax community (climatic climax) for a given region is known as the:
(A) Monoclimax Theory
(B) Polyclimax Theory
(C) Climax-Pattern Hypothesis
(D) Facilitation Model

163. Which part of a Biosphere Reserve is legally protected and allows no human activity?
(A) Buffer Zone
(B) Transition Zone
(C) Core Zone
(D) Restoration Zone

164. The removal of the top fertile layer of soil by wind or water is called:
(A) Soil profile development
(B) Weathering
(C) Sedimentation
(D) Soil erosion

165. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): Biodiversity is not uniformly distributed across the globe.
Reason (R): Factors like latitude, altitude, precipitation, and temperature create varied environmental conditions, leading to a gradient in species richness.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

166. A plant with a very short life cycle that takes advantage of brief periods of favorable conditions in arid environments is called:
(A) A succulent
(B) An ephemeral
(C) A phreatophyte
(D) A perennial

167. Allogenic succession is a type of succession where:
(A) Changes are brought about by the organisms themselves.
(B) The community is in a stable, climax state.
(C) The succession process occurs in a newly formed pond.
(D) Changes are caused by external factors like climate change or soil erosion.

168. What is the most likely consequence of increased global warming on species distribution?
(A) The amount of annual rainfall supporting tree growth.
(B) The presence of decomposers.
(C) The level of solar radiation.
(D) The presence of primary consumers.

169. What is 'character displacement'?
(A) Movement of a species to a new geographical location.
(B) Changes in an organism's character due to environmental pollution.
(C) Greater divergence in sympatric than in allopatric populations of species.
(D) Process of one species being completely replaced by another.

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(D) Corrosion of buildings and monuments.

147. What is the primary role of decomposers in an ecosystem?
(A) To convert solar energy into chemical energy.
(B) To consume producers at the first trophic level.
(C) To recycle nutrients by breaking down dead organic matter.
(D) To regulate the population of herbivores.

148. The study of the distribution of species and ecosystems in geographic space and through geological time is known as:
(A) Ecology
(B) Ethology
(C) Paleontology
(D) Biogeography

149. The 'Indo-Ganga Plain' phytogeographical region of India is largely characterized by:
(A) Alpine vegetation.
(B) Tropical evergreen forests.
(C) Extensive agriculture and riverine forests.
(D) Mangrove swamps.

150. A major approach to the management of natural resources that emphasizes use without depletion is:
(A) Exploitation
(B) Sustainable development
(C) Preservation
(D) Eradication

151. Which soil classification system is most widely used internationally by soil scientists?
(A) Indian Traditional Classification
(B) British Soil Classification
(C) Russian Soil Classification
(D) USDA Soil Taxonomy

152. Leaching of minerals from the topsoil (A-horizon) is a process known as:
(A) Eluviation
(B) Illuviation
(C) Humification
(D) Mineralization

153. A plant that completes its life cycle, from germination to the production of seed, within a single year, is called:
(A) A perennial
(B) A biennial
(C) An annual
(D) An ephemeral

154. The 'Ozone Hole' refers to the seasonal thinning of the ozone layer, which is most pronounced over:
(A) Antarctica
(B) The Equator
(C) The Tropic of Cancer
(D) The Arctic

155. Which statement correctly distinguishes between habitat and niche?
(A) Habitat is the environment where a species lives, while niche is its genetic history.
(B) Niche is the physical location, while habitat is the specific functional role performed.
(C) Habitat and niche are interchangeable scientific terms for the same ecological concept.
(D) Habitat is the address of an organism, while niche is its profession or role.

156. An interaction where one species benefits by inhibiting the growth of another, for instance, through the release of chemical toxins (allelopathy), is a form of:
(A) Mutualism
(B) Amensalism or Competition
(C) Commensalism
(D) Predation

157. The 'stratification' of a community refers to:
(A) The horizontal distribution of species.
(B) The seasonal changes in species composition.
(C) The vertical layering of vegetation.
(D) The relative abundance of different species.

158. Which of these is an example of an ex-situ conservation strategy?
(A) National Park
(B) Biosphere Reserve
(C) Wildlife Sanctuary
(D) Cryopreservation of gametes

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114. The Montreal Protocol is an international treaty designed to:
(A) Protect the ozone layer by phasing out the production of ozone-depleting substances.
(B) Reduce greenhouse gas emissions.
(C) Conserve biological diversity.
(D) Control the transboundary movement of hazardous wastes.

115. Match the pollutants in List I with their major effects in List II.
List I: (Pollutant)
P. CFCs
Q. SO_2
R. CO_2
S. Nitrate fertilizers
List II: (Major Effect)
1. Global warming
2. Eutrophication
3. Acid rain
4. Ozone layer depletion
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

116. The documentation of traditional knowledge related to the use of biodiversity is important for:
(A) Biopiracy
(B) Ensuring equitable sharing of benefits arising from its use.
(C) Replacing modern scientific knowledge.
(D) Limiting access to genetic resources.

117. An endemic species is one which is:
(A) Found all over the world.
(B) On the verge of extinction.
(C) Confined to a particular region and not found anywhere else.
(D) Introduced from another country.

118. Which of the following is an anatomical adaptation in hydrophytes?
(A) Presence of thick cuticle
(B) Poorly developed vascular and mechanical tissues
(C) Sunken stomata
(D) Well-developed root system

119. A transitional community in an ecological succession is known as a:
(A) Climax community
(B) Pioneer community
(C) Sere or seral stage
(D) Sere or seral stage

120. Which of the following is a density-dependent factor that can regulate population size?
(A) Competition for food
(B) A severe flood
(C) A harsh winter
(D) A volcanic eruption

121. The 10 percent law of energy transfer in a food chain was proposed by:
(A) Ernst Haeckel
(B) A.G. Tansley
(C) Raymond Lindeman
(D) Eugene Odum

122. In a forest ecosystem, a pyramid of numbers can be inverted if:
(A) The producers are very large trees, and the primary consumers are small insects.
(B) The primary consumers are larger than the producers.
(C) The number of producers is always greater than the number of consumers.
(D) The ecosystem has very low productivity.

123. The sulfur cycle is different from the nitrogen and carbon cycles because it has a significant:
(A) Gaseous phase only.
(B) Lack of involvement of microorganisms.
(C) Absence of a reservoir in living organisms.
(D) Sedimentary phase in rocks and an atmospheric (gaseous) phase.

124. The fundamental niche of a species is:
(A) The actual range of conditions where it lives, considering all forms of biotic interactions.
(B) The full range of environmental conditions and resources it could potentially occupy and use.
(C) The specific habitat where it is most abundant and find the most favorable growth conditions.
(D) The exact trophic level it occupies within a complex and highly interconnected biotic food web.

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170. Which of these is NOT a principle of conservation biology?
(A) The promotion of monoculture for higher yield.
(B) The preservation of species and communities.
(C) The maintenance of ecological complexity.
(D) The recognition of the intrinsic value of biodiversity.

171. In soil science, 'loam' is a soil type that:
(A) Consists entirely of clay.
(B) Consists entirely of sand.
(C) Is waterlogged and has very low oxygen content.
(D) Has a balanced mixture of sand, silt, and clay, providing good drainage and fertility.

172. Consider the following statements about global environmental change:
1. Global warming leads to a rise in sea levels.
2. The primary cause of the ozone hole is the increase in atmospheric CO_2.
3. Acid rain can lower the pH of soil and water bodies, harming aquatic life.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

173. The 'Ganga Action Plan' in India was initiated primarily to:
(A) Build dams for irrigation.
(B) Promote commercial fishing.
(C) Improve the water quality of the river Ganga.
(D) Prevent floods in the Gangetic plains.

174. Which type of species interaction is represented by the relationship between a fig tree and a fig wasp, where the wasp pollinates the tree and the tree provides a place for the wasp to lay its eggs?
(A) Parasitism
(B) Commensalism
(C) Competition
(D) Obligate Mutualism

175. The measurement of species diversity at a landscape level, incorporating the diversity between different habitats, is known as:
(A) Gamma diversity
(B) Alpha diversity
(C) Point diversity
(D) Niche diversity

176. Which of the following is an anatomical adaptation of plants to low light conditions (sciophytes)?
(A) Thick multi-layered epidermis
(B) Thin leaves with a large surface area and more chlorophyll
(C) A high density of stomata
(D) Extensive root system

177. The replacement of an existing community by another as a result of a disturbance like a forest fire or logging is an example of:
(A) Primary succession
(B) Secondary succession
(C) Autogenic succession
(D) Climax stage

178. The study of the timing of recurring biological events and the causes of their timing with regard to biotic and abiotic forces is called:
(A) Phenology
(B) Morphology
(C) Ethology
(D) Palynology

179. In an aquatic ecosystem, the limiting factor for productivity in the deeper zones is typically:
(A) Water availability
(B) Temperature
(C) Light penetration
(D) Nutrient availability

180. Match the Acts/Policies in List I with their primary focuses in List II.
List I: (Act/Policy)
P. Wildlife (Protection) Act, 1972
Q. Forest (Conservation) Act, 1980
R. Biological Diversity Act, 2002
S. Environment (Protection) Act, 1986
List II: (Primary Focus)
1. Regulates the diversion of forest land for non-forest purposes.
2. An umbrella legislation for the protection and improvement of the environment.
3. Protection of wild animals, birds, and plants.

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4. Conservation of biodiversity and equitable sharing of benefits.

(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-1, R-3, S-4

181. The term 'resource partitioning' helps explain how:
(A) A single species can dominate an entire ecosystem.
(B) Energy flows from one trophic level to the next.
(C) Similar species can coexist in the same community by avoiding direct competition.
(D) Pioneer species colonize a barren land.

182. A soil with a pH value of 8.5 would be considered:
(A) Strongly acidic
(B) Alkaline
(C) Neutral
(D) Slightly acidic

183. The weathering of parent rock is the first step in:
(A) Ecological succession
(B) Nutrient cycling
(C) Decomposition
(D) Soil formation

184. The phenomenon of climate change refers to:
(A) Long-term, significant changes in the average weather patterns of a region or the Earth as a whole.
(B) The daily changes in weather patterns.
(C) The seasonal cycle of summer and winter.
(D) The depletion of the ozone layer in the stratosphere.

185. A species that provides an early warning of environmental damage is known as a/an:
(A) Keystone species
(B) Flagship species
(C) Indicator species
(D) Endemic species

186. The main difference between a food chain and a food web is:
(A) A food chain is a single pathway of energy flow, while a food web consists of multiple interconnected food chains.
(B) A food web only includes producers, while a food chain includes consumers.
(C) A food web is less stable than a food chain.
(D) A food chain represents aquatic ecosystems, while a food web represents terrestrial ecosystems.

187. The Himalayas and the Western Ghats possess:
(A) Vast deserts and grasslands.
(B) The largest populations of a single species.
(C) Only economically valuable timber species.
(D) High species richness and high levels of endemism.

188. Which biome is characterized by long, severe winters and a short growing season, with coniferous trees like pine, spruce, and fir being dominant?
(A) Tundra
(B) Boreal Forest (Taiga)
(C) Temperate Grassland
(D) Tropical Savanna

189. Which statement is incorrect regarding r-selected species?
(A) They are adapted to unstable environments.
(B) They produce many small offspring.
(C) They exhibit high levels of parental care.
(D) They have a short generation time.

190. Arrange the following steps of the nitrogen cycle in a logical sequence, starting from atmospheric nitrogen.
1. Ammonification
2. Denitrification
3. Nitrification
4. Nitrogen Fixation

(A) 4, 1, 3, 2
(B) 2, 3, 1, 4
(C) 4, 3, 1, 2
(D) 1, 4, 3, 2

191. A broad-leaved deciduous forest is a characteristic feature of which geographical region?
(A) Eastern Himalayas
(B) Western Himalayas
(C) Gangetic Plain
(D) Andaman and Nicobar Islands

192. Which of the following is a direct service provided by an ecosystem?

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(A) Nutrient cycling
(B) Pollination of crops
(C) Soil formation
(D) Climate regulation

193. The physical degradation of soil, where soil particles are compacted, reducing porosity and water infiltration, is known as:
(A) Salinization
(B) Soil compaction
(C) Laterization
(D) Leaching

194. Which of the following is a major cause of biodiversity loss?
(A) Introduction of invasive alien species
(B) Afforestation
(C) Creation of wildlife corridors
(D) Sustainable harvesting practices

195. The concept that different environmental factors can substitute for one another in determining the climax community is central to the:
(A) Monoclimax theory
(B) Polyclimax theory
(C) Climax-pattern hypothesis
(D) Initial floristic composition model

196. The growth of a plant towards a light source is an example of:
(A) Geotropism
(B) Thigmotropism
(C) Hydrotropism
(D) Phototropism

197. The productivity of an open ocean is generally low because of:
(A) High pressure in deep waters.
(B) Extremely low temperatures.
(C) The limited availability of nutrients like nitrogen and phosphorus.
(D) The high abundance of large predators.

198. 'Jhum cultivation' or shifting cultivation, practiced in Northeast India, is often cited as a cause of:
(A) Soil conservation
(B) Deforestation and soil erosion
(C) Increased biodiversity
(D) Water pollution

199. What is the primary function of a Sacred Grove?
(A) A site for commercial logging.
(B) A plantation of exotic species.
(C) A designated area for recreational hunting.
(D) Area protected on religious grounds as a biodiversity repository.

200. The ecological pyramid that is always upright and can never be inverted is the:
(A) Pyramid of energy
(B) Pyramid of numbers
(C) Pyramid of biomass
(D) Pyramid of standing crop

201. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): Secondary succession is generally faster than primary succession.
Reason (R): Secondary succession begins in an area where soil and some life forms (like seeds and spores) are already present from the pre-existing community.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

202. Which of the following is a physiological adaptation of an animal to cold temperatures?
(A) Hibernation
(B) Thick fur
(C) Migrating to a warmer region
(D) Large body size (Bergmann's rule)

203. The population characteristic that describes the spatial pattern of individuals (e.g., clumped, uniform, random) is:
(A) Density
(B) Natality
(C) Life Expectancy
(D) Dispersion

204. In the sulfur cycle, a major natural source of atmospheric sulfur dioxide (SO_2) is:
(A) Photosynthesis
(B) Volcanic eruptions
(C) Denitrification
(D) Nitrogen fixation

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(D) The community change is brought about by the organisms of the community themselves.

136. Which of the following is NOT a characteristic of a k-selected species?
(A) Short life expectancy
(B) Stable environment
(C) High competitive ability
(D) Few, large-sized offspring

137. The total amount of living organic matter in an ecosystem at any given time is called:
(A) Primary productivity
(B) Detritus
(C) Standing crop
(D) Humus

138. Consider the following statements about biodiversity hotspots:
1. They must contain at least 1,500 species of vascular plants as endemics.
2. They must have lost at least 70% of their primary vegetation.
3. India has multiple designated biodiversity hotspots including the Western Ghats and the Himalayas.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

139. The interaction between a carnivorous plant like a pitcher plant and an insect is best described as:
(A) Mutualism
(B) Herbivory
(C) Parasitism
(D) Carnivory/Predation

140. Which factor is most critical in distinguishing different terrestrial biomes from each other?
(A) Soil type and topography
(B) Climate, particularly temperature and precipitation
(C) Dominant animal species
(D) Longitude and latitude

141. A 'Keystone species' is a species that:
(A) Is the most abundant in the community.
(B) Is at the top of the food chain.
(C) Has a disproportionately large effect on its environment relative to its abundance.
(D) Is the first to colonize a new habitat.

142. The "Red Data Book" published by IUCN contains lists of:
(A) Economically important plants.
(B) Plants with medicinal properties.
(C) Endemic species of all biodiversity hotspots.
(D) Species that are threatened with extinction.

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143. Which of the following is an example of a man-made ecosystem?
(A) An aquarium
(B) A dense forest
(C) A desert
(D) A large lake

144. The gradual physiological and biochemical adjustment of an organism to changes in its environment is called:
(A) Adaptation
(B) Acclimatization
(C) Succession
(D) Evolution

145. Match the terms in List I with their concepts in List II.
List I: (Term)
P. Carrying Capacity (K)
Q. Biotic Potential (r)
R. Environmental Resistance
S. Niche
List II: (Concept)
1. The functional role of a species in its community.
2. The maximum reproductive rate of a population under ideal conditions.
3. The sum of factors that limit population growth.
4. The maximum population size an environment can sustain.
(A) P-4, Q-2, R-3, S-1
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-2, R-3, S-4

146. Which of the following is NOT a consequence of acid rain?
(A) Increased formation of stratospheric ozone.
(B) Damage to forests and crops.
(C) Acidification of lakes and streams.

(C) Forest resources
(D) Grasslands

218. Laterite soils, commonly found in tropical regions with high rainfall, are characterized by:
(A) Being rich in iron and aluminum oxides and poor in nutrients.
(B) High fertility and organic matter content.
(C) A dark, almost black color due to humus.
(D) A high pH value, making them alkaline.

219. The Kyoto Protocol was an international agreement aimed at:
(A) Banning the use of CFCs.
(B) Conserving wetlands of international importance (Ramsar sites).
(C) Preventing desertification.
(D) Reducing the emission of greenhouse gases.

220. Match the life history traits in List I with their selection types in List II.
List I: (Life History Trait)
P. Rapid development
Q. Delayed reproduction
R. Strong competitive ability
S. Many small offspring
List II: (Selection Type)
1. k-selection
2. r-selection
3. k-selection
4. r-selection
(A) P-2, Q-1, R-3, S-4
(B) P-2, Q-1, R-1, S-2
(C) P-1, Q-2, R-2, S-1
(D) P-2, Q-1, R-3, S-2

221. Which is the correct statement for biodiversity?
(A) It is the occurrence of a single species in a given area.
(B) It is highest in the polar regions due to extreme conditions.
(C) It encompasses the variety of genes, species, and ecosystems.
(D) It remains constant over geological time.

222. The growth pattern of a population that is often followed by a crash when resources are exhausted is the:
(A) S-shaped curve
(B) Logistic growth
(C) Stable equilibrium
(D) J-shaped curve

223. What is the primary function of the buffer zone in a Biosphere Reserve?
(A) Serving area for research, education, and tourism compatible with conservation.
(B) To provide an area for intensive farming and industrial development.
(C) It is a strictly protected area with no human intervention.
(D) It is designated for the relocation of local communities.

224. 'Allelopathy' is a type of interaction where:
(A) Two organisms benefit from each other.
(B) One organism inhibits the growth of another by releasing chemical substances.
(C) One organism feeds on another.
(D) Both organisms are negatively affected by a shared resource.

225. The process of decomposition is fastest in which of the following conditions?
(A) Cold and dry environments.
(B) Warm and moist environments with ample oxygen.
(C) Anaerobic and waterlogged conditions.
(D) Extremely acidic soils.

226. 'Project Tiger', a conservation program in India, was launched in:
(A) 1973
(B) 1972
(C) 1980
(D) 1986

227. Soil 'tilth' refers to:
(A) The nutrient content of the soil.
(B) The water-holding capacity of the soil.
(C) The physical condition of the soil in relation to its suitability for plant growth.
(D) The percentage of organic matter in the soil.

228. An increase in the Earth's average temperature due to the greenhouse effect is known as:
(A) Acidification
(B) Eutrophication
(C) Ozone depletion
(D) Global warming

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229. A plant indicator for overgrazed rangeland would likely be:
(A) A tall, palatable grass species.
(B) A rare and sensitive orchid.
(C) A hardy, unpalatable, or thorny weed.
(D) A species that requires high soil moisture.

230. The Convention on Biological Diversity (CBD) was opened for signature at the:
(A) Stockholm Conference, 1972
(B) Rio Earth Summit, 1992
(C) Johannesburg Summit, 2002
(D) Kyoto Conference, 1997

231. The relative proportion of different age groups in a population is called its:
(A) Population density
(B) Natality rate
(C) Dispersion pattern
(D) Age structure

232. Which of the following is a sedimentary nutrient cycle?
(A) Phosphorus cycle
(B) Carbon cycle
(C) Nitrogen cycle
(D) Oxygen cycle

233. In a deep lake, the bottom zone where light does not penetrate and decomposition is the main activity is called the:
(A) Littoral zone
(B) Limnetic zone
(C) Profundal zone
(D) Benthic zone

234. Gause's Principle of Competitive Exclusion implies that:
(A) Two species with identical niches cannot coexist indefinitely.
(B) Coexistence is possible only if niches are identical.
(C) All competition leads to the extinction of one species.
(D) Niche differentiation is not a result of competition.

235. Which of the following is NOT a major phytogeographical region of India?
(A) Western Himalayas
(B) Deccan Peninsula
(C) Gangetic Plain
(D) Siberian Tundra

236. The Narmada Bachao Andolan primarily focused on:
(A) Deforestation in the Himalayas.
(B) The construction of large dams on the Narmada river.
(C) Industrial pollution in urban areas.
(D) The establishment of a nuclear power plant.

237. The dark-colored, amorphous substance formed by the decomposition of organic matter in soil is called:
(A) Litter
(B) Detritus
(C) Humus
(D) Loam

238. Photochemical smog is a type of air pollution primarily caused by the reaction of:
(A) Sulfur dioxide and water vapor.
(B) Nitrogen oxides and volatile organic compounds in the presence of sunlight.
(C) Carbon monoxide and particulate matter.
(D) Nitrogen oxides and volatile organic compounds in the presence of sunlight.

239. The Ramsar Convention is an international treaty for the conservation and sustainable use of:
(A) Wetlands
(B) Forests
(C) Deserts
(D) Coral reefs

240. Consider the following statements regarding species interactions:
1. Pollination is a form of mutualism where both the plant and the pollinator benefit.
2. Herbivory is a form of predation where the prey is a plant.
3. Symbiosis is a broad term for a close and long-term interaction between two different biological species.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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241. The ability of a community to resist disturbance and remain unchanged is called:
(A) Resilience
(B) Resistance
(C) Stability
(D) Succession

242. Plants that grow best in full sunlight are known as:
(A) Heliophytes
(B) Sciophytes
(C) Mesophytes
(D) Halophytes

243. The Shannon-Wiener index is a measure used in ecology to quantify:
(A) Population density
(B) The rate of succession
(C) Species diversity
(D) The carrying capacity

244. The gradual enrichment of a water body with nutrients, whether natural or artificial, is called:
(A) Biomagnification
(B) Salinization
(C) Acidification
(D) Eutrophication

245. An organism's habitat is best described as:
(A) Its functional role in the ecosystem.
(B) Its position in the food web.
(C) The physical location or environment where it lives.
(D) Its range of tolerance to environmental factors.

246. Which of the following represents ex-situ conservation?
(A) A National Park
(B) A Gene Bank
(C) A Sacred Grove
(D) A Biosphere Reserve

247. The C-horizon in a soil profile consists of:
(A) Humus and topsoil.
(B) Zone of accumulation of leached minerals.
(C) Unweathered bedrock.
(D) Weathered parent rock material.

248. The primary cause for the large-scale decline of vulture populations in India was:
(A) The veterinary use of the drug diclofenac, which is toxic to vultures.
(B) Habitat loss due to deforestation.
(C) A viral disease specific to vultures.
(D) Lack of food due to better disposal of livestock carcasses.

249. Which of the following is a greenhouse gas?
(A) Oxygen (O_2)
(B) Nitrogen (N_2)
(C) Methane (CH_4)
(D) Argon (Ar)

250. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R):
Assertion (A): The realized niche of a species is often smaller than its fundamental niche.
Reason (R): The presence of competitors, predators, and parasites can restrict a species from occupying its full potential range of conditions and resources.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

251. The ability of a community to recover quickly after a disturbance is called:
(A) Resistance
(B) Climax
(C) Stratification
(D) Resilience

252. A 'life history strategy' refers to:
(A) The evolutionary path of a species over geological time.
(B) The pattern of survival and reproduction events typical for a member of the species.
(C) The daily behavioral routine of an organism.
(D) The sequence of communities during ecological succession.

253. Which trophic level has the least amount of available energy in an ecosystem?
(A) Producers
(B) Primary consumers
(C) Tertiary consumers
(D) Secondary consumers

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(C) Mangrove plants (halophytes)
(D) Alpine plants

278. Which of the following is a density-dependent population control factor?
(A) Earthquake
(B) Disease and parasitism
(C) Seasonal climate change
(D) Drought

279. The breakdown of detritus into smaller particles by organisms like earthworms is the first step in decomposition, known as:
(A) Leaching
(B) Catabolism
(C) Humification
(D) Fragmentation

280. The ecological role of a species in its environment is its niche. The 'fundamental niche' refers to:
(A) The broadest possible niche that a species could potentially occupy.
(B) The niche occupied in the presence of competitors.
(C) The smallest niche a species can survive in.
(D) The niche a species occupies in a climax community.

281. The conservation strategy that focuses on protecting large blocks of habitat, including entire ecosystems, is the:
(A) Species-based approach
(B) Ex-situ conservation approach
(C) Ecosystem management approach
(D) Genetic conservation approach

282. The 'A' horizon of the soil is also known as the zone of:
(A) Eluviation
(B) Illuviation
(C) Accumulation
(D) Weathering

283. The primary air pollutant that is a product of incomplete combustion of fossil fuels is:
(A) Sulfur dioxide (SO_2)
(B) Nitrogen dioxide (NO_2)
(C) Ozone (O_3)
(D) Carbon monoxide (CO)

284. Which of the following is a major driver of biodiversity change, often referred to as one of the 'Evil Quartet'?
(A) Sustainable development
(B) Co-extinctions
(C) Ecotourism
(D) Restoration ecology

285. Consider the following statements about the principles of conservation biology:
1. Evolutionary processes are the basis for biodiversity and should be conserved.
2. Ecological complexity should be maintained as it enhances ecosystem stability.
3. Biodiversity has intrinsic value, irrespective of its economic utility to humans.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

286. The ability of a plant to alter its morphology, physiology, or anatomy in response to environmental changes is known as:
(A) Genetic drift
(B) Natural selection
(C) Speciation
(D) Phenotypic plasticity

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287. Which of the following is the most appropriate description of a climax community?
(A) It is in equilibrium with the environment and exhibits long-term stability.
(B) It is the first community to establish in a barren area.
(C) It is characterized by a very high rate of change in species composition.
(D) It consists primarily of r-selected species.

288. The S-shaped growth curve is described by the equation $dN/dt = rN((K–N)/K)$. Here, 'K' represents:
(A) The intrinsic rate of increase.
(B) The carrying capacity of the environment.
(C) The population size at time t.
(D) The initial population size.

289. In the context of the food web, 'top carnivores' are organisms that:
(A) Feed on producers.

poles and higher altitudes.
(D) Species ranges will contract towards the equator.

266. A plant that is physiologically adapted to tolerate high light intensity is a:
(A) Heliophyte
(B) Sciophyte
(C) Hydrophyte
(D) Saprophyte

267. Secondary succession differs from primary succession in that it:
(A) Occurs on newly exposed rock.
(B) Is a much slower process.
(C) Always leads to a desert climax.
(D) Starts in an area that already has soil and some life forms.

268. In population ecology, 'natality' refers to:
(A) The death rate.
(B) The birth rate.
(C) The rate of immigration.
(D) The rate of emigration.

269. The main reservoir for the carbon cycle is:
(A) Rocks and sediments.
(B) Living organisms.
(C) The atmosphere and oceans.
(D) Fossil fuels only.

270. Match the interactions in List I with the examples in List II.
List I: (Interaction)
P. Mutualism
Q. Parasitism
R. Commensalism
S. Competition
List II: (Example)
1. An orchid growing on a tree trunk.
2. Two species of grass vying for water in a field.
3. Mycorrhizal fungi on plant roots.
4. A tapeworm in the human intestine.
(A) P-1, Q-2, R-4, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

271. Which of these biomes is NOT found in India?
(A) Tundra
(B) Tropical Rainforest
(C) Desert
(D) Temperate Broadleaf Forest

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272. A key objective of National Parks and Sanctuaries is:
(A) To promote industrial development.
(B) To provide a safe haven for wildlife through in-situ conservation.
(C) To conduct ex-situ conservation of endangered plants.
(D) To allow unrestricted tourism and commercial activities.

273. The classification of soil based on its developmental stages and diagnostic horizons is known as:
(A) Soil Texture Analysis
(B) Soil Taxonomy
(C) Soil Color Charting
(D) Soil Fertility Indexing

274. The Environment (Protection) Act, 1986 of India was enacted in the aftermath of which disaster?
(A) The Bhopal Gas Tragedy
(B) The London Smog
(C) The Chernobyl Disaster
(D) The Minamata Disease Outbreak

275. The term 'Bioprospecting' refers to:
(A) The illegal trade of wildlife.
(B) The process of monitoring biodiversity loss.
(C) The exploration of biodiversity for commercially valuable genetic and biochemical resources.
(D) The introduction of genetically modified organisms into the environment.

276. In community structure, the term 'physiognomy' refers to:
(A) The genetic makeup of the species.
(B) The functional roles of the species.
(C) The total number of species present.
(D) The external appearance or look of the community.

277. Vivipary, the germination of seeds while still attached to the parent plant, is a characteristic adaptation of:
(A) Xerophytes
(B) Hydrophytes

ANSWERS

1. (B) Assemblage of different plant populations occurring together in a specific area.
A plant community is defined as a collection of different plant populations that live and interact within a specific geographic region. These populations share a common environment and influence each other's growth, survival, and distribution patterns. Understanding these assemblages helps ecologists study the complex relationships between various species and their collective response to the surrounding physical environment.

2. (A) It includes aspects like species richness, stratification, and species dominance.
Community structure encompasses several vital attributes that describe the organization and composition of species within a specific habitat. Key components include species richness, which refers to the total number of species present, and stratification, describing vertical layering. Dominance is also a critical factor, as certain species may exert a significant influence on the overall character of the community.

3. (C) Species richness
Species richness is a fundamental ecological measure representing the total number of different species found within a defined geographic area or unit. It provides a straightforward count of biodiversity without considering the relative abundance of each species. This metric is essential for comparing the biological diversity of different habitats and monitoring changes in ecosystems over a period of time.

4. (D) Simpson's Index
Simpson's Index is a widely used mathematical tool in ecology that calculates species diversity by accounting for both richness and evenness. Unlike simple species counts, it measures the probability that two individuals randomly selected from a sample will belong to the same species. This index provides a more nuanced understanding of community composition by reflecting the relative abundance of species.

5. (A) Both A and R are true and R is the correct explanation of A.
Tropical regions generally exhibit higher species diversity because they have remained evolutionarily stable for millions of years without major disturbances like glaciations. Furthermore, these areas receive high solar energy, leading to greater primary productivity that supports a vast array of organisms. This combination of stability and energy availability allows for narrower niches and greater specialization among tropical plant species.

6. (B) Alpha diversity
Alpha diversity refers to the variety of species found within a single, specific community or local ecosystem. When a scientist focuses on the species richness of a small forest patch, they are measuring diversity at this local scale. This measurement is crucial for understanding the internal composition of a community and comparing the biological health of similar individual habitat patches.

7. (D) Natality
Community attributes describe the collective characteristics of an assemblage of different species, such as stratification, dominance, and species diversity. In contrast, natality is a population-level attribute that refers to the birth rate of individuals within a single species. Therefore, while features like vertical layering are properties of a whole community, birth rates apply only to individual species populations.

8. (A) P-2, Q-4, R-3, S-1
Ecotypes are genetically distinct populations within a species adapted to local conditions, while ecoclines describe gradual changes in species along environmental gradients. Ecads represent populations with non-heritable variations induced by their environment. Finally, an ecotone is a transitional zone where two different communities meet, often exhibiting higher diversity. These terms are essential for describing the complexity of ecological variation.

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(B) Are not preyed upon by other animals in the food web.
(C) Feed on various types of herbivores.
(D) Decompose dead organic matter.

290. The concept of 'ecological pyramids' was first introduced by:
(A) Charles Elton
(B) Charles Darwin
(C) A.G. Tansley
(D) E.P. Odum

291. Mycorrhiza represents a symbiotic association between:
(A) An alga and a fungus.
(B) A bacterium and the roots of a legume.
(C) A fungus and the roots of higher plants.
(D) A plant and a pollinating insect.

292. The 'Sunderbans' in India is a well-known example of which type of ecosystem?
(A) Tropical Rainforest
(B) Temperate Grassland
(C) Alpine Meadow
(D) Mangrove Ecosystem

293. The physical and chemical properties of a soil are primarily determined by its:
(A) Color and temperature
(B) Location on a map
(C) Texture, structure, and composition
(D) Age in years

294. What does the term 'climate change' broadly encompass?
(A) Only the increase in global average temperature.
(B) Long-term shifts in temperatures and weather patterns, including warming, cooling, and changes in precipitation.
(C) Only the depletion of the ozone layer.
(D) The day-to-day fluctuations in local weather.

295. Which of the following is an example of an 'umbrella species' in conservation?
(A) A species that is very common and widespread.
(B) A species that is a major pest.
(C) A microscopic species with no known function.
(D) A species whose conservation indirectly protects many other species within its habitat.

296. Plants showing adaptations to periodic fire, such as thick bark or serotinous cones, are often found in which biome?
(A) Savanna and Chaparral
(B) Tropical Rainforest
(C) Tundra
(D) Aquatic ecosystems

297. The orderly, directional, and predictable change in community composition is called:
(A) Stratification
(B) Zonation
(C) Succession
(D) Fluctuation

298. Life history strategies (r and k selection) represent a trade-off between:
(A) The number of offspring and the amount of parental investment.
(B) Growth and survival.
(C) Predation and competition.
(D) Habitat size and niche breadth.

299. In an ecosystem, the flow of energy is:
(A) Cyclic
(B) Bidirectional
(C) Multidirectional
(D) Unidirectional

300. The concept of 'hotspots of biodiversity' emphasizes the conservation of regions with:
(A) High population density
(B) High endemism and high threat level
(C) High industrial activity
(D) High agricultural productivity

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18. (A) Both A and R are true and R is the correct explanation of A.
Species following a k-selection strategy are typically found in stable environments where competition is intense. These organisms invest significant energy into producing a small number of high-quality offspring and providing them with extensive care. This strategy enhances the competitive ability of the offspring, allowing the population to remain stable near the carrying capacity of their predictable and resource-rich habitat.

19. (C) Production of a large number of offspring
Species with an r-selection strategy are adapted to unstable or unpredictable environments where rapid colonization is advantageous. A typical characteristic of these species is the production of a large number of small offspring with minimal parental investment. This approach maximizes the chances that some individuals will survive and reproduce, allowing the population to grow quickly when favorable conditions temporarily occur.

20. (A) 4, 2, 5, 1, 3
Primary succession on barren land, known as a xerosere, follows a predictable sequence of stages. It begins with the lichen stage, followed by mosses which help build soil. Subsequently, the herb stage develops, leading to the shrub stage as the soil deepens. The process finally culminates in the forest stage, representing the stable climax community for the regional climate.

21. (C) Factors determining carrying capacity and preventing indefinite growth.
Population regulation involves the various biological and environmental factors that limit the size of a population. These factors prevent populations from growing indefinitely and help maintain them near the carrying capacity of their habitat. Regulation can be density-dependent, such as competition and disease, or density-independent, like natural disasters, both of which act to stabilize population numbers within an ecosystem.

22. (B) The position an organism occupies in a food chain.
A trophic level identifies the specific functional position an organism occupies within a food chain or ecological pyramid. Producers form the first level, followed by primary, secondary, and tertiary consumers. This classification helps ecologists track the flow of energy and nutrients through an ecosystem, illustrating how different organisms are connected through their feeding relationships and energy transfer processes.

23. (D) Decomposers
Biotic components of an ecosystem consist of all the living organisms that interact within the environment. Decomposers, such as fungi and bacteria, are vital biotic elements that break down dead organic matter into simpler substances. Unlike abiotic factors like sunlight or soil pH, decomposers are biological entities that play a functional role in nutrient cycling and the overall health of ecosystems.

24. (A) It shows organisms in multiple food chains feeding at various trophic levels.
A food web provides a more realistic view of an ecosystem because most organisms do not feed on a single type of food. It consists of many interconnected food chains, showing that a species can occupy multiple trophic levels simultaneously. This complexity reflects the diverse feeding relationships in nature, which contribute to the overall stability and resilience of the ecological community.

25. (B) P-2, Q-4, R-1, S-3
Ecological pyramids represent different aspects of trophic levels. The pyramid of energy is always upright because energy is lost at each step. The pyramid of numbers shows individual counts, while the pyramid of biomass represents total dry weight. In certain aquatic ecosystems, the biomass pyramid can be inverted because the primary producers have a high turnover rate and lower standing biomass.

26. (A) Solar radiation
Solar radiation is the ultimate source of energy for nearly all ecosystems on Earth. Photosynthetic organisms, such as plants and algae, capture sunlight and convert it into chemical energy stored in organic molecules. This energy is then transferred through various trophic levels as consumers eat producers, fueling the biological processes that sustain life and drive the functioning of the entire biosphere.

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9. (C) Morphological adaptation
Morphological adaptations involve changes in the physical form or external structure of an organism to improve its chances of survival. The development of succulent, water-storing stems in desert plants is a clear example of such a physical modification. This structural change allows these plants to endure prolonged periods of drought by maintaining internal water reserves despite the harsh environment.

10. (A) Increased number of stomata on the upper leaf surface to maximize gas exchange.
Plants adapted to water scarcity typically exhibit features that minimize water loss rather than maximize gas exchange. Increasing stomata on the upper leaf surface would lead to excessive transpiration and dehydration. Instead, desert plants usually have fewer stomata, often located on the lower surface or sunken in pits, and may modify leaves into spines to reduce the surface area.

11. (C) They store large amounts of water in their leaves and stems.
Crassulacean Acid Metabolism is a physiological strategy used by plants in arid environments to conserve water. These plants often exhibit succulence, meaning they store significant amounts of water in specialized tissues within their leaves and stems. This physical storage, combined with nocturnal carbon dioxide fixation, enables them to maintain metabolic processes even during extreme heat and prolonged dry periods.

12. (C) 1 and 3 only
Ecological succession is an orderly and directional process of community change that can begin on barren ground or in disturbed areas. While it follows a predictable sequence, it does not always culminate in a stable climax community due to frequent environmental disturbances. Primary and secondary succession are distinguished by whether the process starts in an area devoid of soil or life.

13. (C) Pioneer species
Pioneer species are the first organisms to colonize a previously uninhabited or barren area during the initial stage of primary succession. These hardy organisms, such as lichens and mosses, are capable of surviving extreme conditions and lack of soil. By breaking down rocks and adding organic matter, they eventually create a more suitable environment for larger and more complex plant species.

14. (D) A relatively stable community in equilibrium with its environment.
The climax stage represents the final phase of ecological succession, where a community reaches a state of relative stability and equilibrium. At this point, the species composition remains constant as long as the environmental conditions do not change significantly. This stable community is well-adapted to the local climate and soil, marking the culmination of the directional changes in succession.

15. (A) Non-heritable phenotypic variations in a plant species caused by the environment.
An ecade, also known as an ecophene, refers to a population within a species that exhibits physical variations due to environmental influences. These phenotypic changes are non-heritable, meaning they are not passed on to offspring if the environment changes. This flexibility allows plants to adjust their growth and appearance to survive in diverse habitats without undergoing permanent genetic modifications.

16. (B) Birth rate
Birth rate is a characteristic that applies specifically to a group of individuals belonging to the same species in a given area. While an individual organism is born and eventually dies, it does not possess a birth rate itself. Instead, the birth rate is a statistical measure used to describe the reproductive output and potential growth of an entire population over time.

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17. (B) Initial slow growth, then rapid growth, then slowing at carrying capacity.
The logistic growth curve describes how a population size increases in a resource-limited environment. It begins with a lag phase of slow growth, followed by an exponential phase as the population expands rapidly. Finally, the growth rate slows down as the population approaches the carrying capacity of the habitat, resulting in a stable S-shaped curve that reflects environmental resistance.

254. The process by which organic nitrogen is converted back into inorganic ammonia (NH3) by decomposers is called:
(A) Nitrification
(B) Denitrification
(C) Nitrogen fixation
(D) Ammonification (Mineralization)

255. A biome that is treeless, has low average temperatures, little precipitation, and a short growing season is the:
(A) Tundra
(B) Desert
(C) Grassland
(D) Temperate forest

256. A species introduced into a new environment where it lacks natural predators and competitors, leading to a rapid population increase and disruption of the native ecosystem, is known as a(n):
(A) Endemic species
(B) Invasive species
(C) Keystone species
(D) Indicator species

257. The 'Kanha National Park' in Madhya Pradesh is well-known for the conservation of:
(A) Asiatic Lion
(B) Barasingha (Swamp Deer)
(C) One-horned Rhinoceros
(D) Snow Leopard

258. The pH of a soil greatly influences:
(A) The availability of nutrients to plants
(B) Soil texture
(C) Soil structure
(D) The soil's parent material

259. A major environmental impact of using coal as a fuel is the release of:
(A) Chlorofluorocarbons
(B) Oxygen
(C) Sulfur dioxide
(D) Clean water vapor

260. Arrange the following global environmental summits/protocols in chronological order:
1. Kyoto Protocol
2. Rio Earth Summit
3. Montreal Protocol
4. Stockholm Conference
(A) 4, 3, 2, 1
(B) 2, 4, 3, 1
(C) 4, 2, 3, 1
(D) 3, 4, 2, 1

261. The 'competitive release' phenomenon is observed when:
(A) Two species evolve to become more similar in the presence of each other.
(B) A predator is introduced into a new ecosystem.
(C) A species expands its niche in response to the removal of a competitor.
(D) A species is conserved in an ex-situ facility.

262. Which of the following statements about the food web is incorrect?
(A) It shows multiple interconnected food chains.
(B) The flow of energy is multidirectional, from consumers back to producers.
(C) It represents a more realistic flow of energy in an ecosystem.
(D) An organism can operate at more than one trophic level.

263. The Western Ghats, Sri Lanka, and Indo-Burma regions are considered global 'hotspots' because of their:
(A) Large desert areas.
(B) Importance for monoculture plantations.
(C) Low species diversity but high population counts.
(D) High number of endemic species and significant habitat loss.

264. The practice of growing crops on level benches constructed on a hillside is known as:
(A) Terrace cultivation
(B) Crop rotation
(C) Strip cropping
(D) Mulching

265. What is the most likely consequence of increased global warming on species distribution?
(A) Species will remain in their current habitats without any change.
(B) All species will become extinct simultaneously.
(C) Species will shift their ranges towards the

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27. (D) Nitrogen fixation
Nitrogen fixation is the biological process where specialized bacteria convert atmospheric nitrogen gas into ammonia. This transformation is essential because most living organisms cannot directly use the nitrogen found in the air. By turning it into a chemical form that plants can absorb, these bacteria make nitrogen available for the synthesis of proteins and other vital biological molecules.

28. (B) Grasshopper
In a terrestrial food chain, primary consumers are herbivores that feed directly on producers like plants. A grasshopper is a classic example of a primary consumer as it consumes vegetation for energy. These organisms form the second trophic level, acting as a vital link between the energy captured by plants and the higher-level consumers, such as birds or small mammals.

29. (C) Gross primary productivity
Gross primary productivity refers to the total rate at which producers in an ecosystem capture solar energy and convert it into chemical energy through photosynthesis. This measurement represents the total amount of organic matter produced before any energy is used for the plant's own respiration. It is a fundamental indicator of the energy available to support the entire biological community.

30. (A) 1 and 2 only
The carbon cycle involves the continuous movement of carbon between the atmosphere and living organisms. Photosynthesis is the primary process that removes carbon dioxide from the air, while respiration by plants and animals returns it. However, human activities like burning fossil fuels significantly impact this cycle by releasing stored carbon back into the atmosphere, contributing to rising greenhouse gas levels.

31. (A) Decomposition
Decomposition is the complex biological process where specialized organisms break down dead organic matter into simpler inorganic substances. This essential ecosystem function releases carbon dioxide, water, and nutrients back into the environment, making them available for use by producers. Without decomposition, nutrients would remain trapped in dead tissues, eventually leading to a collapse of the entire nutrient cycling system.

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32. (B) Rocks and sediments
Unlike the nitrogen or carbon cycles, the phosphorus cycle does not have a significant gaseous phase in the atmosphere. The major reservoirs of phosphorus are found in Earth's rocks and sedimentary deposits. Over time, weathering processes release phosphate ions into the soil and water, where they can be absorbed by plants and integrated into the biological components of various ecosystems.

33. (A) Both A and R are true and R is the correct explanation of A.
The pyramid of energy is always upright because energy transfer between trophic levels is inherently inefficient. According to the ten percent law, only a small fraction of the energy consumed by one level is converted into biomass available for the next level. Most of the energy is lost as heat during metabolic processes, ensuring that energy always decreases at higher levels.

34. (A) Subject to periodic fires and grazing.
Indian grassland ecosystems are frequently shaped by human and natural disturbances, particularly periodic fires and grazing by livestock and wild herbivores. These factors prevent the encroachment of woody plants and maintain the dominance of grasses. Such ecosystems are often found in regions with seasonal rainfall, where the cycles of fire and grazing are essential for maintaining their structural integrity.

35. (C) They receive high nutrient influx from both rivers and the sea.
Estuaries are highly productive because they benefit from a constant supply of nutrients delivered by freshwater rivers and incoming oceanic tides. This nutrient-rich environment supports a vast array of primary producers, including phytoplankton and marsh grasses. The resulting high productivity provides abundant food and habitat for numerous species, making estuaries critical nurseries for many commercially important fish and shellfish.

minimal disturbance to nature. Sanctuaries may allow limited human activities under regulation, but National Parks are primarily dedicated to preserving the entire ecological community in its pristine state.

54. (B) Reconcile biodiversity conservation with sustainable human development.
A Biosphere Reserve is a unique conservation area designed to balance the protection of biological diversity with sustainable human development. This concept involves a zoning system that allows for strict protection in a core area while promoting research, education, and sustainable resource use in the surrounding zones. By involving local communities, Biosphere Reserves aim to create a harmonious relationship between people and their environment.

55. (C) 1 and 3 only
Soil conservation involves various practices to prevent erosion and maintain soil fertility. Terracing on steep slopes effectively slows water runoff, reducing the loss of topsoil. Conversely, overgrazing by livestock can lead to significant degradation by removing protective vegetation. While afforestation is a key conservation method that stabilizes soil, some statements correctly identify that human activities must be managed to protect land.

56. (A) Sand, silt, and clay
Soil texture is determined by the relative proportions of different-sized mineral particles, specifically sand, silt, and clay. These proportions influence essential soil properties such as water-holding capacity, drainage, and aeration. For example, sandy soils drain quickly due to large particles, while clayey soils retain more water. A balanced mixture of these particles creates loam, which is generally considered ideal for most plant growth.

57. (C) Cation Exchange Capacity (CEC)
Cation Exchange Capacity is a critical soil property that measures the soil's ability to hold and exchange positively charged ions, or cations. These ions include essential plant nutrients like calcium, potassium, and magnesium. Soil particles, especially clay and organic matter, have negative charges that attract these nutrients, preventing them from leaching away and ensuring they remain available for absorption by plant roots.

58. (A) Pedogenesis
Pedogenesis is the complex biological and physical process of soil formation from parent rock material. It involves weathering, organic matter accumulation, and the development of distinct layers over long periods of time. Factors such as climate, topography, organisms, and time all interact to determine the final characteristics of the soil, resulting in the diverse soil types found across different regions of the world.

59. (D) Soil profile
A soil profile is a vertical cross-section of the soil that reveals its various horizontal layers, known as horizons. It extends from the ground surface down to the underlying unweathered parent rock. Each horizon has unique physical and chemical characteristics, such as color, texture, and organic content. Studying the soil profile is essential for understanding the history, fertility, and developmental stage of the soil.

60. (A) P-4, Q-2, R-1, S-3
Soil horizons are distinct layers with unique characteristics. The O horizon consists of fresh organic matter, while the A horizon is the mineral-rich topsoil containing humus. The B horizon is the subsoil where leached minerals accumulate, and the C horizon contains partially weathered parent material. This sequence represents a typical well-developed soil profile, illustrating the progression from organic surface to inorganic bedrock.

61. (C) Atmospheric pressure
Soil formation is driven by several major environmental factors, including climate, parent material, topography, and biological organisms. Climate influences the rate of weathering and organic matter decomposition, while parent material determines the initial mineral composition. Topography affects water drainage and erosion patterns. However, atmospheric pressure does not play a direct or significant role in the chemical and physical processes that create soil.

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can effectively partition resources and coexist more stably.

45. (C) Predation
The physical environment consists of abiotic factors such as temperature, soil composition, and sunlight, which influence the survival and growth of organisms. In contrast, predation is a biotic factor because it involves the interaction between two living organisms. While physical factors set the background conditions for life, biotic factors like predation represent the biological pressures that further shape ecosystem dynamics.

46. (D) Symbiotic fungi
The biotic environment comprises all the living organisms and their biological interactions within an ecosystem. Symbiotic fungi are biotic components because they are living entities that form complex relationships with other organisms, such as plants. Unlike abiotic factors like rainfall or soil texture, these fungi actively participate in biological processes like nutrient absorption and energy exchange within the community.

47. (A) Tundra
The tundra is a major terrestrial biome characterized by extremely cold temperatures and the presence of permafrost, which is permanently frozen subsoil. These harsh conditions limit vegetation to low-growing forms such as mosses, lichens, and dwarf shrubs. The short growing season and lack of deep soil prevent the growth of large trees, creating a vast, treeless landscape adapted to severe cold.

48. (B) High endemism and tropical evergreen forests
The Western Ghats of India are recognized as a global biodiversity hotspot due to their exceptional species richness and high levels of endemism. This region is predominantly covered by lush tropical evergreen forests that support many species found nowhere else on Earth. The complex topography and heavy monsoon rainfall contribute to the unique biological diversity and ecological importance of this mountain range.

49. (B) Alpine Forest
Madhya Pradesh features a variety of forest types, primarily tropical deciduous forests, which are adapted to the state's seasonal climate and moderate rainfall. However, alpine forests are not found in this region as they are restricted to high-altitude areas like the Himalayas. The state's vegetation is instead dominated by species suited to tropical moist and dry deciduous conditions, as well as thorn forests.

50. (A) Preserve biodiversity at all levels, from genes to ecosystems.
Conservation biology is a multidisciplinary science focused on protecting and restoring Earth's biological diversity. Its core goal is to preserve biodiversity at every level, including genetic variation, species populations, and entire ecosystems. By using scientific principles to manage natural resources, this field aims to prevent extinctions and maintain the essential ecological processes that sustain life on our planet for future generations.

51. (A) Both A and R are true and R is the correct explanation of A.
In-situ conservation focuses on protecting and managing wild species within their natural habitats. This approach is highly effective because it preserves not only the species but also the ecological interactions and environmental conditions they need to survive. Establishing protected areas like National Parks and Wildlife Sanctuaries is a primary strategy used to ensure species can thrive in their original ecosystems.

52. (D) Integrated management of land, water, and vegetation resources.
Watershed management is an integrated approach to managing the natural resources within a specific drainage basin. It focuses on the sustainable use of land, water, and vegetation to ensure ecological health and provide resources for human use. By coordinating the management of these interconnected components, this process helps reduce soil erosion, improve water quality, and maintain the overall productivity of the landscape.

53. (C) National Parks have higher protection and most human activities are prohibited.
In India, National Parks provide a higher level of protection for wildlife and ecosystems compared to Wildlife Sanctuaries. Within a National Park, most human activities, including grazing and timber collection, are strictly prohibited to ensure

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36. (D) Competition
Competition is an interaction between organisms or species in which both parties are harmed by their shared use of a limited resource. This resource could be food, water, territory, or sunlight. In a competitive relationship, even the "winner" experiences a reduction in fitness due to the energy and time expended to acquire the resource, ultimately affecting growth and reproduction.

37. (C) Symbiosis (Mutualism)
A lichen represents a mutualistic relationship where a fungus and an alga or cyanobacterium live together for mutual benefit. The alga produces food through photosynthesis, which it shares with the fungus. In return, the fungus provides structural protection, moisture, and minerals absorbed from the environment. This symbiotic partnership allows lichens to survive in harsh conditions where neither organism could live alone.

38. (B) An interaction where an organism feeds on plants.
Herbivory is a specific type of biological interaction where an animal, known as a herbivore, consumes plant tissues for energy and nutrients. This relationship is a fundamental part of food chains, as herbivores transfer the energy captured by plants to higher trophic levels. While it can harm individual plants, herbivory also influences plant evolution, community structure, and nutrient cycling.

39. (D) Pollination
Pollination is the essential process in plant reproduction where pollen grains are transferred from the male anther to the female stigma of a flower. This transfer can occur within the same flower or between different plants, often facilitated by wind, water, or animal pollinators like bees. Successful pollination is a prerequisite for fertilization and the subsequent development of seeds and fruits.

40. (A) It is synonymous with the term 'habitat'.
The concept of a niche is distinct from a habitat, although they are related. While a habitat is the physical place where an organism lives, a niche describes the organism's total role in its ecosystem. This includes how it uses resources, its interactions with other species, and the specific environmental conditions it can tolerate, effectively representing the species' functional profession.

41. (C) Two species competing for the same limiting resource cannot coexist at constant population values.
Gause's principle of competitive exclusion states that two species with identical ecological requirements cannot coexist indefinitely when resources are limited. One species will inevitably be more efficient at utilizing the resource, leading to the decline and eventual local extinction of the other. For coexistence to occur, competing species must evolve different niches or use resources in distinct ways to reduce direct competition.

42. (B) P-2, Q-3, R-4, S-1
Mutualism is a positive interaction where both species benefit. Competition results in negative effects for both parties due to shared resource use. Predation involves one species benefiting by consuming the other, which is harmed. Commensalism is a relationship where one organism benefits while the other remains unaffected. These interactions are fundamental in shaping the structure and dynamics of biological communities.

43. (D) Competing species to share resources by using them differently.
Resource partitioning is an ecological process that allows similar species to coexist in the same habitat by reducing direct competition. Instead of competing for the exact same resource, species evolve to use different parts of the resource, feed at different times, or occupy different micro-habitats. This specialization enables multiple species to share a limited resource pool without leading to competitive exclusion.

44. (B) Character displacement
Character displacement occurs when two competing species evolve different physical or behavioral traits to reduce niche overlap and minimize competition. This phenomenon is typically observed in areas where the species live together compared to where they live apart. By developing distinct characteristics, such as different beak sizes or feeding times, the species

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62. (D) Minerals, organic matter, water, and air.
Soil is a complex mixture consisting of four primary components: minerals, organic matter, water, and air. Minerals provide the structural framework and nutrients, while organic matter, or humus, improves fertility and structure. Water and air occupy the pore spaces between particles, which is essential for the survival of soil organisms and plant roots. The balanced interaction of these components determines soil health.

63. (A) Acid rain
The release of sulfur dioxide and nitrogen oxides into the atmosphere primarily results from burning fossil fuels. These gases react with water vapor and sunlight to form sulfuric and nitric acids, which eventually fall back to Earth as acid rain. This phenomenon can lower the pH of soil and water bodies, causing extensive damage to forests, aquatic life, and human-made structures.

64. (B) Certain atmospheric gases trap outgoing infrared radiation, warming the Earth's surface.
The greenhouse effect is a natural process where specific atmospheric gases, such as carbon dioxide and methane, absorb infrared radiation emitted from the Earth's surface. Instead of escaping into space, this energy is trapped, warming the atmosphere and maintaining temperatures suitable for life. However, human activities have increased the concentration of these gases, leading to an enhanced greenhouse effect and global warming.

65. (A) 3, 1, 4, 2
India has enacted several key environmental protections over the decades. Project Tiger was launched in 1973 to conserve the national animal. This was followed by the Water Act in 1974 and the Air Act in 1981 to control pollution. Finally, the comprehensive Environment Protection Act was enacted in 1986, providing a broader framework for managing various environmental issues across the entire country.

66. (A) Chlorofluorocarbons (CFCs)
Chlorofluorocarbons are human-made chemicals that were once widely used in refrigeration, air conditioning, and aerosol sprays. When released into the atmosphere, they eventually reach the stratosphere, where sunlight breaks them down to release chlorine atoms. These atoms act as catalysts in the destruction of ozone molecules, leading to the seasonal thinning of the ozone layer, which protects Earth from harmful ultraviolet radiation.

67. (C) A plant species or community that indicates the status of specific environmental conditions.
A plant indicator is a species or community that reflects the health or specific conditions of its environment through its presence, absence, or physical state. These plants are sensitive to changes in factors like soil pH, pollution levels, or water availability. By observing these indicators, scientists can assess environmental quality and monitor the impacts of human activities or natural changes on various ecosystems.

68. (D) 1986
The Environment Protection Act was enacted in India in 1986, shortly after the Bhopal Gas Tragedy. This umbrella legislation was designed to provide a comprehensive framework for the protection and improvement of the environment. it empowers the central government to coordinate the activities of various authorities, set environmental standards, and take necessary measures to prevent and control pollution across the country.

69. (C) Ground-level ozone (O3)
Secondary air pollutants are not emitted directly from a source but form in the atmosphere through chemical reactions between primary pollutants. Ground-level ozone is a classic example, produced when nitrogen oxides and volatile organic compounds react in the presence of sunlight. Unlike the protective ozone layer in the stratosphere, this tropospheric ozone is a harmful component of smog that damages human health and vegetation.

70. (B) The variety of life on Earth at all its levels, from genes to ecosystems.
Biodiversity is a broad term that encompasses the entire variety of life found on Earth. It includes genetic diversity within individual species, the richness of different species within a community, and the diverse types of ecosystems across the planet. This biological variety is essential for maintaining ecosystem functions, providing

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Biotic interactions are fundamental in driving evolutionary processes and maintaining the structure of biological communities.

88. (B) P-3, Q-1, R-4, S-2
In-situ conservation protects species in their natural habitats, such as Biosphere Reserves, while ex-situ conservation involves external facilities like Botanical Gardens. Watershed management often utilizes check dams to manage water resources and reduce erosion. Soil conservation includes techniques like contour ploughing to maintain land productivity. Matching these methods with their appropriate examples illustrates the diverse strategies used to protect biodiversity and natural resources.

89. (C) Tropical deciduous forests and scrublands.
The Deccan Peninsula in central and southern India is predominantly characterized by tropical deciduous forests and extensive scrublands. This vegetation type is adapted to the region's seasonal climate, which features distinct wet and dry periods. Many trees in these forests shed their leaves during the dry months to conserve water. This vast landscape supports a wide range of wildlife and is essential for regional ecological balance.

90. (A) Any material or substance occurring in nature which can be exploited for economic gain.
A natural resource is any material, substance, or organism found in nature that humans can use to meet their needs or provide economic value. These include renewable resources like timber and water, as well as non-renewable resources like minerals and fossil fuels. The management of these resources is crucial for sustaining human societies while ensuring the long-term health and productivity of the planet's ecosystems.

91. (D) Soil color is not related to its composition or fertility.
Soil properties like texture and water-holding capacity are essential for agriculture, with clay and sand representing opposite ends of the drainage spectrum. However, stating that soil color is unrelated to composition is incorrect. In reality, soil color is a vital indicator of its chemical makeup and fertility; for instance, dark colors often signify high organic matter content, while reddish tones indicate iron oxides.

92. (B) A horizon (Topsoil)
The A horizon, commonly referred to as the topsoil, is the soil layer richest in organic matter, or humus. This horizon is also where most biological activity occurs, hosting roots, fungi, and numerous soil organisms. The presence of decomposing plant and animal material gives this layer its dark color and high fertility, making it the most critical horizon for supporting plant growth and agricultural productivity.

93. (C) Greenhouse gases like CO_2 and CH4
Global warming is primarily caused by the rising concentration of greenhouse gases in the atmosphere, especially carbon dioxide and methane. These gases trap heat radiated from the Earth's surface, preventing it from escaping into space. While many of these gases occur naturally, human activities such as burning fossil fuels and intensive agriculture have greatly increased their levels, leading to a significant increase in average global temperatures.

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94. (D) Air pollution, particularly SO_2 levels
Lichens are highly effective bio-indicators for monitoring air quality because they absorb water and nutrients directly from the atmosphere. They are particularly sensitive to sulfur dioxide, which can disrupt their growth and survival even at low concentrations. By observing the presence or absence of specific lichen species in a given area, scientists can assess the level of air pollution and track changes in atmospheric health.

95. (A) Provide a framework for the coordination of central and state authorities in environmental protection.
One of the primary objectives of the Environmental Protection Act of 1986 is to establish a strong legal framework for coordinating the actions of central and state governments. This coordination is essential for effectively managing environmental issues and implementing national standards. The act empowers the government to take comprehensive measures to prevent pollution, improve environmental quality, and respond to industrial disasters, ensuring a unified approach to conservation.

96. (B) Trophic diversity
Biodiversity is typically recognized at three major levels: genetic diversity, species diversity,

79. (A) Broad base and a tapering top.
A rapidly growing population is characterized by a high proportion of young individuals, which creates a broad base in an age structure pyramid. This large juvenile cohort indicates high reproductive potential and future expansion as these individuals reach breeding age. The tapering top reflects fewer elderly individuals, which is typical of populations where birth rates significantly exceed death rates, leading to overall population increase.

80. (D) 1, 2 and 3
Species interactions are diverse and categorized by their effects on the participants. Parasitism harms the host while benefiting the parasite. Commensalism provides a benefit to one species while the other remains unaffected. Amensalism is a relationship where one organism is negatively impacted while the other experiences no effect. All three descriptions accurately reflect the fundamental biological interactions that shape community dynamics in natural ecosystems.

81. (B) Population regulation
Ecosystem functions refer to the essential biological and chemical processes that occur within an ecosystem, such as energy flow, productivity, and decomposition. These processes maintain the system's health and sustain its living components. While population regulation is an important ecological phenomenon, it is traditionally considered a characteristic of individual populations or community interactions rather than a primary functional role performed by the entire ecosystem itself.

82. (A) Primary producers
In most terrestrial ecosystems, an upright pyramid of biomass reflects the fact that primary producers have the largest total dry weight. This occurs because energy is lost at each successive trophic level, meaning there is less energy available to support the growth and maintenance of consumer biomass. Consequently, the massive quantity of plants and other producers forms the broad base that supports all higher levels.

83. (C) Denitrification
Denitrification is the biological process that completes the nitrogen cycle by returning nitrogen to the atmosphere. Specialized bacteria in anaerobic environments, such as waterlogged soils, convert nitrates back into gaseous nitrogen. This process prevents the excessive accumulation of nitrates in the soil and maintains the balance of nitrogen between the terrestrial environment and the atmospheric pool, ensuring the cycle continues sustainably.

84. (D) GPP - Respiration (R)
Net primary productivity represents the actual rate at which energy is stored as biomass by producers after accounting for their own metabolic needs. It is calculated by subtracting the energy used by plants for respiration from the total energy captured through photosynthesis, or gross primary productivity. This remaining energy is what is ultimately available for consumption by herbivores and other organisms in the ecosystem.

85. (C) Mangrove wetlands
Mangrove wetlands are unique ecosystems dominated by salt-tolerant trees like Rhizophora and Avicennia. These plants have specialized adaptations, such as aerial roots and salt-secreting glands, to survive in saline, waterlogged, and anaerobic soils found in coastal areas. These wetlands provide critical habitats for many species and serve as essential coastal protection against storms and erosion, acting as productive transitional zones between land and sea.

86. (B) Joseph Grinnell
The concept of the ecological niche was first comprehensively defined by Joseph Grinnell in the early twentieth century. He described the niche as the specific habitat and physical conditions required by a species to survive and reproduce. While the definition has since expanded to include functional roles and biological interactions, Grinnell's early work laid the foundational understanding of how species are uniquely situated within their environments.

87. (D) A bee pollinating a flower.
A biotic interaction involves the relationship between two living organisms. A bee pollinating a flower is a perfect example, as it represents a mutualistic relationship where both the insect and the plant benefit. In contrast, responses to temperature or light are interactions between an organism and its abiotic environment.

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resources for humans, and ensuring the resilience of the biosphere against environmental changes.

71. (D) Understanding changes and developing conservation strategies.
Monitoring and documenting biodiversity are essential for tracking how species and ecosystems respond to various environmental pressures. This information allows scientists to identify which species are under threat and where conservation efforts should be focused. By understanding long-term changes in biological variety, policymakers can develop effective strategies to protect endangered habitats and manage natural resources sustainably for future benefit.

72. (A) Habitat destruction and fragmentation
Habitat destruction and fragmentation are the primary drivers of global biodiversity loss. As human activities like agriculture, urbanization, and logging expand, they destroy the natural homes of countless species and break remaining habitats into smaller, isolated patches. This loss of space and connectivity reduces population sizes, limits genetic exchange, and makes species more vulnerable to extinction, significantly altering the balance of ecosystems.

73. (C) Have high richness, high endemism, and are under threat.
Biodiversity hotspots are specific geographic regions that are exceptionally rich in species and contain many organisms found nowhere else on Earth, a phenomenon known as endemism. However, these areas are also under significant threat from human activities and have lost a large portion of their original natural vegetation. Protecting these hotspots is a global priority because they contain a vast proportion of Earth's unique biological variety.

74. (A) Conserving components of biodiversity outside their natural habitats, such as in zoos or seed banks.
Ex-situ conservation involves the protection of endangered species or genetic material outside of their natural environments. This approach includes the use of botanical gardens, zoos, and specialized facilities like seed or gene banks. By maintaining species in controlled settings, ex-situ conservation provides a backup against extinction in the wild and offers opportunities for research, education, and eventual reintroduction into restored habitats.

75. (A) Both A and R are true and R is the correct explanation of A.
The logistic growth model is considered more realistic than the exponential model because it accounts for the limited resources available in any natural environment. As a population grows, it encounters increasing environmental resistance, which eventually causes the growth rate to slow down. This process stabilizes the population size at the carrying capacity, reflecting the actual sustainable limit of the habitat for that species.

76. (B) Reduce water loss through transpiration by humidifying a microenvironment.
Sunken stomata are a specialized physical adaptation found in many plants living in dry environments. By being located in deep pits rather than on the leaf surface, these stomata create a small, humid microenvironment that reduces the water vapor pressure gradient between the leaf and the air. This significantly slows the rate of transpiration, helping the plant conserve vital water in arid conditions.

77. (C) Pioneer species are typically replaced by species that are more competitive in stable conditions.
During ecological succession, the initial pioneer species are gradually replaced by other organisms as the environment changes. Pioneers are hardy and grow quickly but are often poor competitors. As soil develops and conditions stabilize, more competitive and long-lived species, such as shrubs and trees, move in. These later-successional species are better at utilizing resources in stable environments, eventually leading to a mature community.

78. (D) Facilitation
Facilitation is a key mechanism of ecological succession where early colonizing species modify their environment in ways that make it more suitable for later species. For example, pioneer plants may add nutrients to the soil or provide shade that helps different seedlings grow. Although these changes might eventually make the habitat less ideal for the pioneers themselves, they are essential for driving the successional process forward.

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and ecosystem diversity. These levels represent the variety of genes within species, the richness of different species, and the diversity of habitats and biological communities. While trophic levels describe the feeding positions of organisms, "trophic diversity" is not considered a formal, standard level of biodiversity used in ecological and conservation sciences.

97. (B) Norman Myers
The concept of biodiversity hotspots was developed by British ecologist Norman Myers in 1988. He identified specific regions that contained an exceptional concentration of endemic species while simultaneously facing significant habitat loss. His work provided a critical framework for prioritizing global conservation efforts, focusing resources on the areas where the highest biological variety is most at risk from human activities and environmental degradation.

98. (A) Flagship species approach
The flagship species approach is a conservation strategy that uses a charismatic or well-known species, such as the tiger or giant panda, to garner public support and funding. By focusing on a single, appealing organism, conservationists can protect its entire habitat, which indirectly benefits numerous other species. This method effectively raises awareness and encourages community involvement in broader biodiversity protection efforts through a recognizable biological symbol.

99. (C) Rate of change in species composition between communities along a gradient.
Beta diversity measures the variation in species composition between different communities or habitats within a larger region. It reflects the rate at which species are replaced as one moves along an environmental gradient or from one ecosystem type to another. Understanding beta diversity is essential for identifying unique habitats and determining how biological variety is distributed across a landscape, which informs regional conservation planning.

100. (D) Halophytes
Halophytes are specialized plants adapted to growing in environments with high salt concentrations, such as coastal marshes and saline deserts. These plants have evolved various physiological and anatomical mechanisms to cope with osmotic stress, including salt-secreting glands and the ability to maintain high internal osmotic pressure. Their presence is a key indicator of saline soil conditions, where most other plant species would struggle to survive.

101. (C) Polyclimax theory
The polyclimax theory suggests that a single region can support several different, stable climax communities rather than just one. These various climaxes are determined by local factors such as soil type, topography, and moisture levels, in addition to the regional climate. This perspective acknowledges that environmental heterogeneity allows for multiple stable ecological states, providing a more complex view of the final stages of ecological succession.

102. (A) Both A and R are true and R is the correct explanation of A.
An ecotone is a transitional zone where two distinct ecological communities meet, often resulting in higher species diversity. This phenomenon, known as the edge effect, occurs because the ecotone contains a mix of species from both adjoining habitats along with organisms uniquely adapted to the transition. Consequently, these areas are ecologically rich and provide diverse niches that support a wide variety of biological life.

103. (D) Experiencing exponential growth with no limiting factors.
A J-shaped growth curve is characteristic of a population expanding rapidly under ideal conditions with abundant resources and no limiting factors. During this phase, the population size increases at a constant percentage rate, leading to an exponential surge. However, such growth is usually temporary in nature, as the population eventually encounters environmental resistance or resource depletion, which can lead to a sudden population crash.

104. (A) The maximum number of individuals of a species that an environment can sustainably support.
Carrying capacity refers to the maximum population size of a species that a given environment can sustain indefinitely without degrading the habitat. This limit is determined by the availability of essential resources such as

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food, water, and space, as well as environmental factors like predation and disease. When a population reaches its carrying capacity, its growth rate typically stabilizes, resulting in a balanced population size.

105. (C) Detritivores
Detritivores are organisms that obtain their energy and nutrients by feeding on detritus, which is dead organic matter from plants and animals. These organisms, including earthworms and various insects, play a crucial role in ecosystems by initiating the decomposition process. By breaking down large pieces of organic material into smaller particles, detritivores facilitate the work of microbial decomposers and help recycle essential nutrients.

106. (A) Nitrogen cycle
A gaseous cycle is a type of nutrient cycle where the primary reservoir of the element is found in the atmosphere. The nitrogen cycle is a classic example, as nearly seventy-eight percent of the air consists of nitrogen gas. This element moves between the atmosphere and living organisms through processes like fixation and denitrification, distinguishing it from sedimentary cycles where the main reservoir is in Earth's crust.

107. (D) The realized niche of A was smaller than its fundamental niche due to competition.
When two species compete for similar resources, their actual distribution, or realized niche, is often more restricted than the full range of conditions they could potentially occupy, known as the fundamental niche. In this case, Species A expanded its range once its competitor was removed, demonstrating that biological interactions like competition had previously limited its presence. This observation highlights the dynamic nature of ecological niches in communities.

108. (D) 1, 2 and 3
Plants have evolved specific adaptations to survive in diverse environments. Hydrophytes possess aerenchyma tissue for buoyancy and gas exchange in water. Xerophytes feature sunken stomata and thick cuticles to minimize water loss in arid conditions. Halophytes maintain high osmotic pressure in their cell sap to absorb water from saline soils. All these adaptations are vital for the survival of plants in their respective ecological habitats.

109. (C) Light intensity
Physical environmental factors are the non-living, abiotic components that influence organisms within an ecosystem. Light intensity is a primary physical factor that affects essential processes such as photosynthesis and plant growth. Unlike biotic factors like competition, parasitism, or pollination, which involve interactions between living organisms, physical factors set the background environmental conditions and resource availability that shape the overall structure of biological communities.

110. (D) A pristine tropical evergreen rainforest from a hydroelectric project.
Silent Valley National Park in Kerala is famous for a historic environmental movement that successfully prevented the construction of a hydroelectric dam. The campaign was focused on protecting a pristine tropical evergreen rainforest, which is one of the last undisturbed areas of its kind in India. This forest is home to numerous rare and endangered species, making its conservation a significant milestone in Indian environmental history.

111. (A) Madhya Pradesh
Madhya Pradesh holds the distinction of having the largest area under forest cover among all states in India. The state's vast forests are predominantly of the tropical deciduous type, supporting a rich diversity of flora and fauna. This extensive forest cover is essential for regional biodiversity, climate regulation, and providing livelihoods for local communities, reflecting the state's significant role in national forest conservation efforts.

112. (B) Illuviation
Illuviation is the soil-forming process where fine particles, minerals, and organic matter leached from upper layers accumulate in a lower horizon. This typically occurs in the B horizon, often leading to the formation of a dense, nutrient-rich layer. This process is the counterpart to eluviation and is fundamental in the development of distinct soil horizons, influencing the chemical and physical properties of the subsoil.

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113. (B) Enrichment of nutrients, leading to excessive algal growth.
Eutrophication is the process where a water body becomes overly enriched with nutrients, typically nitrogen and phosphorus. This enrichment often results from agricultural runoff or sewage discharge, triggering an explosion of algal growth. As these algae die and decompose, they deplete dissolved oxygen in the water, which can lead to the death of fish and other aquatic organisms, severely damaging the entire ecosystem.

114. (A) Protect the ozone layer by phasing out the production of ozone-depleting substances.
The Montreal Protocol is a highly successful international treaty designed to protect the stratospheric ozone layer. It established a schedule for phasing out the production and use of ozone-depleting substances, particularly chlorofluorocarbons. By reducing these chemicals, the protocol aims to allow the ozone layer to recover, thereby protecting Earth from the harmful effects of increased ultraviolet radiation, such as skin cancer and ecological damage.

115. (A) P-4, Q-3, R-1, S-2
Different pollutants have specific environmental impacts. Chlorofluorocarbons are primarily responsible for ozone layer depletion, while sulfur dioxide is a major cause of acid rain. Carbon dioxide is the main greenhouse gas contributing to global warming. Nitrate fertilizers, when washed into water bodies, lead to eutrophication. Understanding these connections is essential for developing targeted environmental policies and mitigation strategies to address diverse pollution issues.

116. (D) Limiting access to genetic resources.
Documenting traditional knowledge is a strategic move to protect indigenous resources and prevent unauthorized exploitation. By creating a formal record of how biological resources are used by local communities, legal barriers can be established to limit access by entities seeking to patent these resources without permission. This ensures that the original knowledge holders maintain control over their biological heritage and receive fair benefits from its use.

117. (C) Confined to a particular region and not found anywhere else.
An endemic species is an organism that is naturally restricted to a specific geographic location, such as an island, a mountain range, or a particular country. Because of their limited distribution, these species are often more vulnerable to extinction if their habitat is disturbed. Endemism is a key factor used to identify biodiversity hotspots and prioritize areas for conservation efforts to protect unique biological variety.

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118. (B) Poorly developed vascular and mechanical tissues
Hydrophytes, or plants adapted to living in water, often exhibit poorly developed vascular and mechanical tissues. Since these plants are supported by the buoyancy of water, they do not require strong structural tissues like lignin for support. Similarly, because they are surrounded by water, they have less need for complex vascular systems to transport moisture, reflecting an anatomical adaptation to their specialized, liquid environment.

119. (D) Sere or seral stage
A sere, or seral stage, refers to any intermediate community that develops during ecological succession. These stages represent the transitional phases between the initial pioneer community and the final stable climax stage. Each seral stage has its own characteristic species and environmental conditions, which gradually change as the process of succession continues toward a state of equilibrium with the regional climate and soil.

120. (A) Competition for food
Density-dependent factors are biological influences that vary in their impact based on the size of the population. Competition for food is a classic example, as it becomes more intense as the population density increases. This increased competition can lead to lower birth rates or higher mortality, helping to regulate the population size. In contrast, factors like floods or volcanic eruptions are density-independent events.

121. (C) Raymond Lindeman
The ten percent law of energy transfer was proposed by Raymond Lindeman in 1942. This

170. (A) The promotion of monoculture for higher yield.
Conservation biology is guided by principles that aim to protect biological variety and ecosystem complexity. It emphasizes preserving species, maintaining ecological stability, and recognizing the intrinsic value of nature. In contrast, promoting monoculture is not a principle of conservation, as it reduces biodiversity and can make ecosystems more vulnerable to pests and environmental changes. Conservation instead focuses on protecting the diverse interactions and genetic variety that sustain healthy, resilient biological communities.

171. (D) Has a balanced mixture of sand, silt, and clay, providing good drainage and fertility.
Loam is a highly desirable soil type that consists of a balanced mixture of sand, silt, and clay. This combination provides the benefits of each particle size: sand ensures good drainage and aeration, while silt and clay help retain moisture and essential nutrients. Because of its excellent structure and fertility, loam is considered ideal for most agricultural crops and plant growth, supporting a healthy and productive environment for roots and soil organisms.

172. (C) 1 and 3 only
Global environmental changes have various interconnected impacts. Global warming causes sea levels to rise due to melting ice and thermal expansion, while acid rain lowers the pH of water bodies, harming aquatic life. However, it is important to distinguish between these issues; for example, the ozone hole is primarily caused by chlorofluorocarbons rather than carbon dioxide. Understanding these specific causes and effects is essential for developing effective environmental policies and mitigation strategies.

173. (C) Improve the water quality of the river Ganga.
The Ganga Action Plan was a major environmental initiative launched in India to address the severe pollution in the river Ganga. Its primary goal was to improve water quality by diverting and treating domestic sewage and industrial waste before it enters the river. By reducing the pollutant load, the plan aimed to restore the river's ecological health and ensure safe water for the millions of people who depend on it for religious and practical purposes.

174. (D) Obligate Mutualism
The relationship between fig trees and fig wasps is a classic example of obligate mutualism, where both species depend entirely on each other for survival and reproduction. The wasp pollinates the fig flowers, while the tree provides a specialized place for the wasp to lay its eggs and for its larvae to develop. Without the wasp, the tree cannot produce seeds, and without the tree, the wasp cannot complete its life cycle.

175. (A) Gamma diversity
Gamma diversity refers to the total species richness across a large geographic region or landscape that contains multiple habitats. it accounts for both the diversity within individual communities and the variation in species composition between them. This broad-scale measure provides a comprehensive view of regional biodiversity, helping ecologists and conservationists understand how biological variety is distributed across diverse environments and prioritize large-scale areas for protection and management.

176. (B) Thin leaves with a large surface area and more chlorophyll
Sciophytes, or plants adapted to low light environments, exhibit specific anatomical features to maximize their photosynthetic efficiency. These plants often have thin leaves with a large surface area, which helps them capture as much of the limited available light as possible. Additionally, they may contain more chlorophyll per unit area or have specialized chloroplast arrangements to make the most of low light intensities, allowing them to thrive in shaded forest floors.

177. (B) Secondary succession
Secondary succession is the process of community change that occurs after a major disturbance has removed an existing community but left the soil intact. Events like forest fires, logging, or abandoned farmland can trigger this process. Because soil and some biological remains like seeds are already present, secondary succession typically proceeds much faster than primary succession, eventually leading to the re-establishment of a stable community that may resemble the original one.

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land and water while respecting the needs of local communities and preserving biological diversity.

130. (A) Both A and R are true and R is the correct explanation of A.
The phosphorus cycle is classified as a sedimentary cycle because its primary reservoir is found in Earth's rocks and mineral deposits. Unlike nitrogen or carbon, phosphorus does not have a significant gaseous phase in the atmosphere under normal conditions. It moves through the ecosystem primarily through the weathering of rocks, absorption by plants from the soil, and eventual return to sediments through decomposition and geologic processes.

131. (C) The arrangement of soil particles into aggregates.
Soil structure describes how individual soil particles, such as sand, silt, and clay, are clumped together into larger units called aggregates or peds. This arrangement determines the size and distribution of pore spaces, which in turn influences water movement, aeration, and root penetration. A well-developed soil structure is essential for maintaining a healthy environment for plants and soil organisms, distinguishing it from the simple soil texture.

132. (D) Why r- and k-selection involve a suite of co-evolving traits rather than single characteristics.
Pleiotropy, the phenomenon where one gene affects multiple traits, helps explain why life history strategies like r- and k-selection involve integrated groups of characteristics. Instead of evolving independently, traits like reproductive rate, lifespan, and offspring size often change together because they are genetically linked. This results in the distinct suites of co-evolving traits that characterize organisms adapted to either unstable or stable environmental conditions.

133. (C) Biomagnification
Biomagnification is the process where the concentration of persistent toxic substances increases as they move up the food chain. Organisms at lower trophic levels absorb small amounts of these pollutants, which then accumulate in the tissues of the predators that eat them. Consequently, top predators can end up with dangerously high levels of toxins, even if the initial concentration in the environment was relatively low, posing a significant ecological risk.

134. (B) Mangrove (Avicennia)
Mangrove plants like Avicennia live in waterlogged, anaerobic soils where roots cannot easily obtain oxygen. To survive, they have developed specialized aerial roots called pneumatophores that grow upwards out of the mud. These structures feature small pores that allow the plant to take in oxygen from the air and transport it to the submerged root system, representing a vital morphological adaptation to their unique coastal environment.

135. (D) The community change is brought about by the organisms of the community themselves.
Autogenic succession is a type of community change driven by the activities and influences of the organisms living within that community. As plants grow, they modify their environment by altering soil nutrients, changing light levels, and increasing organic matter. These biological modifications eventually make the habitat more suitable for new species and less ideal for the current residents, pushing the process of ecological succession forward through internal biological drivers.

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136. (A) Short life expectancy
Species with a k-selection strategy are characterized by traits that favor survival in stable, competitive environments. These include a long life expectancy, large body size, and a high ability to compete for resources. They produce a few, well-cared-for offspring rather than many small ones. A short life expectancy is instead a typical trait of r-selected species, which are adapted to rapid reproduction in unpredictable or disturbed habitats.

137. (C) Standing crop
Standing crop refers to the total mass of living organic matter, or biomass, present in an ecosystem at a specific point in time. It provides a snapshot of the biological material available within the community. While primary productivity measures the rate of new organic matter production, the standing crop represents the current accumulation of that matter, serving as an important indicator of the ecosystem's structural complexity and energy storage.

154. (A) Antarctica
The "ozone hole" refers to a severe seasonal thinning of the stratospheric ozone layer, which occurs most dramatically over Antarctica. This phenomenon is caused by the chemical reactions of ozone-depleting substances, like chlorofluorocarbons, which are enhanced by the unique cold conditions and polar stratospheric clouds found in the region. The resulting increase in ultraviolet radiation reaching the Earth's surface has significant implications for human health and the environment in the southern hemisphere.

155. (D) Habitat is the address of an organism, while niche is its profession or role.
The distinction between habitat and niche is fundamental in ecology. An organism's habitat is the specific physical location or environment where it lives, essentially its "address." In contrast, its niche is its "profession," describing the functional role it plays in its ecosystem. This role includes how the organism obtains energy, its interactions with other species, and how it responds to and influences its physical and biological surroundings.

156. (B) Amensalism or Competition
Allelopathy is a biological phenomenon where an organism produces chemicals that inhibit the growth or survival of other species. This interaction can be categorized as amensalism, where one species is harmed while the other is unaffected, or as a form of competition for space and resources. Many plants use allelopathy to reduce competition from neighbors, effectively using chemical toxins to secure their own dominance and ensure better access to light, water, and nutrients.

157. (C) The vertical layering of vegetation.
Stratification refers to the vertical layering of different plant species within a community based on their height and growth forms. For example, a forest often has distinct layers such as the forest floor, herb layer, shrub layer, understory, and canopy. This vertical organization allows multiple species to coexist by utilizing different light levels and environmental conditions, increasing the overall structural complexity and biodiversity of the ecological community.

158. (D) Cryopreservation of gametes
Cryopreservation is an advanced ex-situ conservation strategy that involves freezing biological material, such as seeds, gametes, or embryos, at extremely low temperatures. This method allows genetic material to be preserved for long periods without loss of viability. Unlike in-situ methods like National Parks, cryopreservation protects biodiversity in a controlled, artificial setting, providing a vital safeguard for endangered species and maintaining genetic diversity for future research and potential reintroduction efforts.

159. (A) Commensalism
The relationship between cattle egrets and grazing cattle is an example of commensalism. As cattle move through the grass, they flush out insects, which the egrets then easily catch and eat. In this interaction, the egret benefits significantly from the increased food availability, while the cattle are neither helped nor harmed. This type of relationship illustrates how one species can gain an advantage from the behavior of another without affecting its well-being.

160. (B) Tropical Rainforest
Tropical rainforests are characterized by high temperatures and abundant year-round precipitation, receiving more annual rainfall than any other terrestrial biome. This consistent moisture, combined with warmth, supports incredibly high primary productivity and exceptional species diversity. The dense vegetation and multi-layered structure of these forests are a direct result of the high precipitation levels, which drive the rapid cycling of nutrients and sustain the vast biological variety found in these ecosystems.

161. (B) Reduce water loss by opening stomata only at night.
Crassulacean Acid Metabolism is a physiological adaptation that allows plants to minimize water loss in hot, dry environments. These plants open their stomata at night to take in carbon dioxide when temperatures are cooler and humidity is higher, which significantly reduces transpiration. During the day, they keep their stomata closed to conserve water while using the stored carbon dioxide for photosynthesis, representing a highly efficient strategy for survival in arid climates.

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146. (A) Increased formation of stratospheric ozone.
Acid rain is a harmful environmental phenomenon caused by atmospheric pollutants that lowers the pH of precipitation. Its consequences include significant damage to forests, crops, and aquatic life, as well as the corrosion of buildings and monuments. However, acid rain is not involved in the formation of stratospheric ozone. In fact, the pollutants that cause acid rain are entirely different from the processes and chemicals that influence the ozone layer.

147. (C) To recycle nutrients by breaking down dead organic matter.
Decomposers, such as bacteria and fungi, perform a fundamental role in ecosystems by breaking down dead organic material into simple inorganic substances. This process releases essential nutrients like nitrogen and phosphorus back into the soil and water, where they can be reused by producers. By recycling these materials, decomposers ensure the continuous flow of nutrients through the food web, maintaining the overall productivity and health of the environment.

148. (D) Biogeography
Biogeography is the scientific study of how species and ecosystems are distributed across geographic space and through geological time. It explores the patterns of biodiversity and the various factors, such as continental drift, climate change, and biological evolution, that have shaped where organisms live today. By understanding these distributions, biogeographers can gain insights into the history of life and predict how species might respond to future environmental changes.

149. (C) Extensive agriculture and riverine forests.
The Indo-Ganga Plain is a vast phytogeographical region in India characterized by its fertile alluvial soil and extensive river systems. Much of the original vegetation has been replaced by intensive agriculture, making it a critical area for national food security. The remaining natural vegetation often consists of riverine forests and grasslands, which are adapted to the seasonal flooding and high moisture levels typical of this flat, productive landscape.

150. (B) Sustainable development
Sustainable development is a management approach that aims to meet current human needs without compromising the ability of future generations to meet theirs. In the context of natural resources, it emphasizes using materials like timber and water in a way that does not deplete them or harm the environment. This principle balances economic growth with social equity and environmental protection, ensuring long-term ecological stability and resource availability for all.

151. (D) USDA Soil Taxonomy
The USDA Soil Taxonomy is one of the most widely used and detailed soil classification systems internationally. It organizes soils into a hierarchical structure based on their measurable physical, chemical, and biological properties, as well as their developmental history. This systematic approach allows scientists to communicate clearly about soil types and predict how they will behave under different management practices, making it a vital tool for agriculture and environmental science.

152. (A) Eluviation
Eluviation is the soil-forming process where minerals and fine particles are washed downward from the upper layers of the soil by infiltrating water. This leaching typically occurs in the A horizon, often leaving it lighter in color and lower in nutrient content. The materials removed during eluviation are then deposited in a lower layer through the process of illuviation, contributing to the development of distinct soil horizons over time.

153. (C) An annual
An annual plant is one that completes its entire life cycle, from germination and growth to flowering and seed production, within a single year or growing season. After producing seeds, the original plant dies. This strategy allows plants to thrive in environments with seasonal changes, ensuring their survival through seeds during unfavorable periods. Annuals are common in both natural ecosystems and agriculture, where they often exhibit rapid growth and high reproductive output.

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valuable tool for environmental assessment and conservation management.

186. (A) A food chain is a single pathway of energy flow, while a food web consists of multiple interconnected food chains.
A food chain provides a simple, linear representation of how energy moves from producers to various consumers. However, in nature, most organisms have diverse diets and participate in multiple feeding relationships. A food web reflects this complexity by showing numerous interconnected food chains. This more realistic model illustrates how energy can flow through many different pathways, contributing to the overall stability and resilience of the entire ecological community.

187. (D) High species richness and high levels of endemism.
The Himalayas and the Western Ghats are two of India's most significant biological regions, recognized globally for their exceptional species richness. They contain a vast array of plants and animals, many of which are endemic, meaning they are found nowhere else on Earth. This high biological variety and uniqueness make these areas critical for conservation. Protecting these regions is essential for maintaining both national and global biodiversity and preserving unique evolutionary lineages.

188. (B) Boreal Forest (Taiga)
The boreal forest, also known as taiga, is a vast terrestrial biome found in northern latitudes. It is characterized by long, severe winters and a short growing season. The vegetation is dominated by cold-tolerant coniferous trees such as pine, spruce, and fir. These forests play a significant role in the global carbon cycle and provide critical habitat for many species adapted to the harsh, cold environment and seasonal extremes of the northern wilderness.

189. (C) They exhibit high levels of parental care.
Species with an r-selection strategy are adapted to produce many offspring quickly in unpredictable or disturbed environments. A typical trait is the production of a large number of small offspring with very little or no parental care. This maximizes the chance that some will survive in a changing landscape. In contrast, high levels of parental care are characteristic of k-selected species, which invest more energy into a few high-quality offspring for better competition.

190. (A) 4, 1, 3, 2
The nitrogen cycle follows a logical sequence to move nitrogen through the environment. It begins with nitrogen fixation, converting atmospheric nitrogen into ammonia. This is followed by ammonification, where organic nitrogen is also turned into ammonia. Nitrification then converts ammonia into nitrates that plants can use. Finally, denitrification returns nitrogen gas to the atmosphere, completing the cycle and maintaining the balance of this essential nutrient in the biosphere.

191. (A) Eastern Himalayas
Broad-leaved deciduous forests are a characteristic feature of the Eastern Himalayas, where the climate supports a diverse range of tree species that shed their leaves seasonally. This region receives significant rainfall and experiences varied temperatures, creating a rich environment for these forests. The high species diversity and complex structure of these forests provide essential habitats for many unique animals and contribute to the overall biological richness of this mountainous phytogeographical region.

192. (B) Pollination of crops
Ecosystem services are the many benefits that humans receive from healthy natural environments. Pollination of crops is a direct service provided by various animals, particularly insects like bees. This process is essential for the production of many fruits, vegetables, and seeds that form a major part of the human diet. By facilitating plant reproduction, these pollinators support agricultural productivity and food security, illustrating the vital link between biodiversity and human well-being.

193. (B) Soil compaction
Soil compaction occurs when soil particles are pressed together, reducing the volume of pore spaces between them. This is often caused by heavy machinery, frequent trampling, or poor agricultural practices. Compaction significantly decreases soil porosity and slows water infiltration, which can lead to increased runoff and erosion. It also restricts root growth and

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162. (A) Monoclimax Theory
The monoclimax theory, proposed by Frederic Clements, suggests that every region has a single, stable climax community toward which all ecological successions eventually proceed. According to this view, the regional climate is the ultimate factor that determines the composition of this final community. Regardless of the starting point or local variations, the theory argues that the vegetation will eventually reach a uniform state of equilibrium dictated by the prevailing climatic conditions.

163. (C) Core Zone
The core zone of a Biosphere Reserve is a strictly protected area where human activity is generally prohibited. Its primary purpose is to preserve the ecosystem and its species in their natural state, serving as a baseline for monitoring environmental changes. By minimizing human disturbance, the core zone ensure the long-term conservation of biodiversity and provides a safe haven for wild populations, maintaining the ecological integrity of the most sensitive parts of the reserve.

164. (D) Soil erosion
Soil erosion is the physical process where the fertile top layer of soil is removed by natural forces like wind and water, often accelerated by human activities such as deforestation and overgrazing. This loss of topsoil reduces land productivity, as it takes away the most nutrient-rich and organic-laden portion of the soil profile. Effective land management and conservation practices are essential to prevent erosion and protect the soil resources necessary for agriculture and ecosystems.

165. (A) Both A and R are true and R is the correct explanation of A.
Biodiversity is not spread evenly across the Earth but follows distinct geographic patterns. Factors such as latitude, altitude, and climate create a wide variety of environmental conditions that influence species richness. For instance, tropical regions near the equator generally support many more species than polar areas. These gradients in diversity are a result of the complex interplay between physical environments and the evolutionary history of biological life.

166. (B) An ephemeral
An ephemeral is a plant with a very short life cycle, often completing its growth and reproduction in just a few weeks following rare rainfall events in arid regions. These plants survive long dry periods as seeds, germinating rapidly when moisture becomes available. By quickly producing seeds before the water disappears, ephemerals avoid the stresses of prolonged drought, representing a highly effective survival strategy for plants living in unpredictable and harsh desert environments.

167. (D) Changes are caused by external factors like climate change or soil erosion.
Allogenic succession refers to community changes that are driven by external environmental factors rather than by the organisms themselves. These factors can include long-term climate shifts, volcanic eruptions, or major soil erosion events. Unlike autogenic succession, where plants modify their own habitat, allogenic changes are imposed from the outside, often leading to large-scale shifts in community composition and ecosystem structure as species respond to the new environmental pressures.

168. (A) The amount of annual rainfall supporting tree growth.
Increased global warming can significantly alter regional weather patterns, particularly the amount and distribution of annual rainfall. These changes in precipitation directly affect the ability of different tree species to survive and reproduce in their current locations. As moisture levels shift, the geographic range of forests may change, with some areas becoming more suitable for tree growth while others become too dry to sustain large vegetation.

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169. (C) Greater divergence in sympatric than in allopatric populations of species.
Character displacement is the phenomenon where two similar species evolve more distinct traits when they live in the same area compared to when they live separately. This divergence reduces niche overlap and minimizes direct competition for resources, allowing the species to coexist more stably. By developing different physical or behavioral characteristics, such as beak size or feeding times, these sympatric populations can effectively partition their shared environment and resources.

138. (A) 1 and 2 only
Biodiversity hotspots are identified based on specific criteria: containing at least fifteen hundred endemic vascular plant species and having lost seventy percent of their primary vegetation. While India does have several such regions, scientific definitions strictly focus on these two measures of endemism and threat. This approach helps prioritize international conservation efforts toward areas with the most unique biological variety that is also under the greatest immediate risk.

139. (D) Carnivory/Predation
The interaction between a pitcher plant and an insect is a form of predation or carnivory, where the plant acts as the predator. Pitcher plants have evolved specialized leaves that trap insects to supplement their nutrient intake, particularly nitrogen, in nutrient-poor soils. Once trapped, the insects are digested by enzymes, providing the plant with essential minerals. This unique relationship demonstrates how some plants have adapted to thrive in harsh environments.

140. (B) Climate, particularly temperature and precipitation
Climate is the most critical factor in determining the distribution and characteristics of different terrestrial biomes. Specifically, variations in average temperature and annual precipitation patterns dictate which types of vegetation can grow in a region. These abiotic factors set the primary conditions for life, influencing soil development and the types of animals that can survive, ultimately defining the broad ecological categories such as desert, forest, or tundra.

141. (C) Has a disproportionately large effect on its environment relative to its abundance.
A keystone species is one whose influence on an ecosystem's structure and function is far greater than its population size or biomass would suggest. These species play a critical role in maintaining the balance of their biological community. If a keystone species is removed, the ecosystem often undergoes dramatic changes, potentially leading to a loss of diversity and a shift in the entire community structure, highlighting its fundamental importance.

142. (D) Species that are threatened with extinction.
The Red Data Book, published by the International Union for Conservation of Nature, is a comprehensive global list of the conservation status of biological species. It categorizes organisms based on their risk of extinction, identifying those that are critically endangered, endangered, or vulnerable. This vital resource helps scientists and policymakers track biodiversity loss, prioritize conservation actions, and develop international agreements to protect the most threatened species on our planet.

143. (A) An aquarium
An aquarium is a classic example of a man-made, or artificial, ecosystem created and maintained by human intervention. Unlike natural ecosystems like forests or lakes, an aquarium requires external energy and management to sustain its biological components. Humans control the species composition, nutrient levels, and physical conditions, making it a simplified model used for study, education, or decoration while illustrating the basic principles of ecological interactions in a controlled setting.

144. (B) Acclimatization
Acclimatization is the process where an individual organism makes gradual physiological or biochemical adjustments to changes in its environment. This can include adapting to different temperatures, altitudes, or humidity levels over a short period. Unlike evolutionary adaptation, which occurs over many generations through genetic changes, acclimatization is a reversible phenotypic response that allows an organism to maintain its internal balance and function effectively in varying environmental conditions.

145. (A) P-4, Q-2, R-3, S-1
Carrying capacity represents the maximum population an environment can sustain, while biotic potential is the maximum reproductive rate under ideal conditions. Environmental resistance is the sum of all factors that limit population growth, preventing it from reaching its full potential. Finally, a niche describes the specific functional role and resource use of a species within its community. Understanding these concepts is essential for studying population dynamics and species interactions.

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178. (A) Phenology
Phenology is the study of the timing of seasonal biological events, such as flowering, migration, and leaf fall, in relation to environmental factors like temperature and rainfall. These recurring events are critical for the survival and reproduction of many species. By tracking changes in phenology, scientists can monitor the impacts of climate change on ecosystems, as many organisms are shifting their life cycle events in response to warming temperatures and altered weather patterns.

179. (C) Light penetration
In aquatic ecosystems, light penetration is the primary limiting factor for productivity in deeper water zones. Since photosynthesis requires sunlight, the rate of organic matter production decreases as light intensity fades with depth. This creates distinct vertical zones: the upper euphotic zone where light is abundant, and the deeper aphotic zone where there is insufficient light for photosynthesis. Consequently, the deeper zones rely on organic matter drifting down from above to support life.

180. (A) P-3, Q-1, R-4, S-2
India has a robust framework of environmental laws, each with a specific focus. The Wildlife Protection Act safeguards animals and plants, while the Forest Conservation Act regulates land use. The Biological Diversity Act ensures the sustainable use and fair sharing of biological resources. Finally, the Environment Protection Act serves as an umbrella law for broad environmental management. Together, these regulations provide a comprehensive approach to protecting the nation's rich natural heritage and biological variety.

181. (C) Similar species can coexist in the same community by avoiding direct competition.
Resource partitioning is an ecological mechanism that enables similar species to live together in the same environment by using resources in different ways. For example, birds might feed at different heights in a tree or eat different sizes of seeds. This specialization reduces direct competition, allowing multiple species to share a limited resource pool. By avoiding overlap in their ecological niches, these species can coexist more stably within a biological community.

182. (B) Alkaline
Soil pH is a measure of the acidity or alkalinity of the soil solution, which significantly affects nutrient availability and microbial activity. A pH value of seven is neutral, while values below seven are acidic. A pH of eight point five indicates that the soil is alkaline, which is often found in arid regions where minerals like calcium carbonate accumulate. Understanding soil pH is essential for selecting appropriate crops and managing soil fertility effectively for plant growth.

183. (D) Soil formation
The weathering of parent rock is the fundamental first step in the process of soil formation, or pedogenesis. This involves the physical breakdown and chemical alteration of rocks into smaller particles through the action of water, temperature changes, and biological organisms. Over long periods, these mineral particles combine with organic matter to create the distinct layers of a soil profile, providing the essential foundation for plant growth and supporting diverse terrestrial ecosystems.

184. (A) Long-term, significant changes in the average weather patterns of a region or the Earth as a whole.
Climate change refers to long-term, significant shifts in Earth's average weather patterns, including changes in temperature, precipitation, and wind. While climate has always varied naturally, recent changes are largely driven by human activities that increase greenhouse gas concentrations. These shifts have broad impacts, including rising sea levels, more frequent extreme weather events, and changes in the distribution of species, posing significant challenges for both natural ecosystems and human societies worldwide.

185. (C) Indicator species
An indicator species is an organism whose presence, absence, or health serves as an early warning of environmental damage or changes in an ecosystem. These species are often highly sensitive to specific pollutants or physical shifts. By monitoring indicator species, such as certain lichens for air quality or amphibians for water health, scientists can detect ecological problems before they become severe, providing a

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fundamental ecological principle states that when energy is transferred from one trophic level to the next, only about ten percent is stored as biomass. The rest is lost as heat during respiration and other metabolic processes. This law explains why food chains are typically short and why higher trophic levels have less energy.

122. (A) The producers are very large trees, and the primary consumers are small insects.
A pyramid of numbers represents the total count of individuals at each trophic level. In a forest, this pyramid can become inverted because a few massive producers, such as trees, can support a much larger number of small primary consumers, like herbivorous insects. Despite the large number of insects, the total biomass of the trees is still much greater, illustrating the difference between count and energy.

123. (D) Sedimentary phase in rocks and an atmospheric (gaseous) phase.
The sulfur cycle is unique because it features both a significant sedimentary phase and a gaseous phase. Sulfur is stored in Earth's crust in minerals and rocks, but it also enters the atmosphere as sulfur dioxide through volcanic eruptions and the burning of fossil fuels. This dual nature involves complex biological and chemical transformations, moving the element through terrestrial, aquatic, and atmospheric components of the ecosystem.

124. (B) The full range of environmental conditions and resources it could potentially occupy and use.
The fundamental niche represents the entire potential range of environmental conditions and resources a species could utilize in the absence of biological constraints. It describes the species' tolerance for abiotic factors like temperature and moisture without considering competition or predation. In nature, however, species usually occupy a narrower realized niche due to their interactions with other organisms that limit their distribution and resource use.

125. (A) 4, 3, 1, 2
A well-developed soil profile follows a standard vertical sequence of horizons. It begins at the surface with the O horizon, composed of organic matter. Below this is the A horizon, or topsoil, followed by the B horizon, where leached minerals accumulate. The sequence ends with the C horizon, which consists of partially weathered parent material. This logical order reflects the process of soil development from organic surface to bedrock.

126. (D) Parasitism
Parasitism is a biological interaction where one organism, the parasite, lives on or inside another organism, known as the host. The parasite benefits by obtaining nutrients and resources from the host, which is harmed by the relationship. While the host may suffer from reduced fitness or disease, parasites typically do not kill their hosts immediately, as they rely on them for long-term survival and reproduction.

127. (A) Savannah-type grasslands with scattered trees
Grasslands in Madhya Pradesh are typically of the savannah type, featuring extensive areas of grass interspersed with scattered trees. These ecosystems are adapted to the region's seasonal rainfall and are often maintained by periodic fires and grazing. They provide essential habitats for various wildlife, including herbivores like the Barasingha, and are an important component of the state's diverse ecological landscape, reflecting a balance between forest and open land.

128. (B) Protecting forests from commercial logging by hugging trees.
The Chipko movement was a groundbreaking environmental campaign in the Indian Himalayas where local villagers, particularly women, protected trees from being felled. By literally hugging the trees, they prevented commercial loggers from destroying the forests they relied on for survival. This non-violent resistance emphasized the link between forest conservation and local livelihoods, becoming a global symbol for community-based environmental activism and the protection of natural resources.

129. (B) UNESCO
The concept of Biosphere Reserves was launched by UNESCO in 1971 as part of its "Man and the Biosphere" program. The initiative aims to establish a worldwide network of protected areas that represent major ecosystems. By combining conservation with sustainable development and scientific research, these reserves serve as living laboratories for testing approaches to managing

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reduces the oxygen available to soil organisms, negatively impacting overall soil health and land productivity.

194. (A) Introduction of invasive alien species
The introduction of invasive alien species is a major driver of global biodiversity loss. These species, when brought to new environments, often lack natural predators and can outcompete native species for resources like food and space. This can lead to the decline or even extinction of local flora and fauna, significantly altering ecosystem structure and function. Managing invasive species is a critical challenge for conservationists aiming to protect native biological variety.

195. (C) Climax-pattern hypothesis
The climax-pattern hypothesis suggests that the final community in ecological succession is determined by the total environmental pattern of a region. It argues that various factors, such as soil, moisture, and topography, can substitute for one another in shaping the climax. This view rejects the idea of a single climatic climax, instead proposing that multiple stable states are possible depending on the complex interplay of diverse environmental influences at a specific location.

196. (D) Phototropism
Phototropism is a biological phenomenon where an organism, typically a plant, grows or moves in response to a light source. In plants, this is usually positive phototropism, where the stem grows toward the light to maximize its ability to perform photosynthesis. This process is driven by the hormone auxin, which accumulates on the shaded side of the stem, causing those cells to elongate and effectively bending the plant toward the light.

197. (C) The limited availability of nutrients like nitrogen and phosphorus.
The productivity of the open ocean is generally low compared to coastal areas because essential nutrients like nitrogen and phosphorus are often in short supply. While sunlight may be abundant in the upper layers, these nutrients tend to sink to the deep ocean floor where they are unavailable to photosynthetic organisms. Without a consistent supply of nutrients, the growth of phytoplankton is limited, which in turn restricts the entire oceanic food web.

198. (B) Deforestation and soil erosion
Jhum cultivation, also known as shifting cultivation, involves clearing forest land for agriculture by burning vegetation. While it has been a traditional practice in Northeast India, its increasing frequency due to population pressure has led to significant deforestation. The removal of forest cover leaves the soil exposed to heavy rains, resulting in severe soil erosion and loss of fertility. This unsustainable cycle poses a major threat to both regional biodiversity and long-term land productivity.

199. (D) Area protected on religious grounds as a biodiversity repository.
Sacred groves are patches of forest that are traditionally protected by local communities based on religious beliefs or cultural significance. These areas are often dedicated to local deities and are shielded from logging and hunting. Because of this long-term protection, sacred groves serve as vital repositories of biodiversity, often containing rare or endemic species that have disappeared from the surrounding landscape, representing an important form of community-based in-situ conservation.

200. (A) Pyramid of energy
The pyramid of energy is the only ecological pyramid that is always upright and can never be inverted. This is because energy is lost as heat at each successive trophic level due to the laws of thermodynamics and metabolic processes. As energy moves from producers to consumers, only a small portion is available for the next level, ensuring that the total energy always decreases, reflecting the unidirectional flow of energy through an ecosystem.

201. (A) Both A and R are true and R is the correct explanation of A.
Secondary succession is generally a faster process than primary succession because it occurs in areas where soil is already established. Following a disturbance like a forest fire or abandoned farming, some life forms, such as seeds, spores, and soil microorganisms, often remain. These biological legacies provide a head start for the re-establishment of a community, allowing the successional stages to proceed more rapidly toward a stable climax state than on barren rock.

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is impossible, and the zone is inhabited by organisms adapted to cold, dark conditions and low oxygen levels. The primary activity here is decomposition, as detritus from the upper layers sinks to the bottom. This zone is a critical part of the lake's nutrient cycle, though it supports less biomass than the sunlit layers.

234. (A) Two species with identical niches cannot coexist indefinitely.
Gause's Principle of Competitive Exclusion states that two species competing for the exact same limiting resources cannot live together in the same place indefinitely. If their ecological niches are identical, one species will inevitably use the resources more efficiently, leading to the decline and eventual local extinction of the other. For similar species to coexist, they must evolve differences in their niches, such as using different food sources or being active at different times.

235. (D) Siberian Tundra
India is a geographically diverse country with several distinct phytogeographical regions, such as the Himalayas, the Deccan Peninsula, and the Gangetic Plain, each supporting unique plant life. However, the Siberian Tundra is not a region found in India; it is located in the northernmost parts of Russia. While India does have high-altitude alpine zones that resemble tundra, the actual Siberian Tundra biome is a latitudinal region that belongs to a completely different part of the world.

236. (B) The construction of large dams on the Narmada river.
The Narmada Bachao Andolan is a well-known social and environmental movement in India that protested the construction of several large dams along the Narmada river. The movement highlighted the potential for large-scale environmental damage and the displacement of thousands of local and tribal people from their homes and lands. It became a significant symbol for the debate over large-scale development projects versus the protection of ecosystems and the rights of local communities.

237. (C) Humus
Humus is the dark, organic material formed in soil from the partial decomposition of plant and animal matter by soil microorganisms. It is a critical component of healthy soil, as it improves structure, increases water-holding capacity, and provides a slow-release source of nutrients for plants. Because it is chemically stable and persists for long periods, humus is essential for long-term soil fertility and supports a wide range of biological activity within the terrestrial ecosystem.

238. (D) Nitrogen oxides and volatile organic compounds in the presence of sunlight.
Photochemical smog is a harmful type of air pollution that forms when primary pollutants like nitrogen oxides and volatile organic compounds react with each other in the presence of sunlight. This reaction creates secondary pollutants, including ground-level ozone, which can cause respiratory problems in humans and damage vegetation. This smog is most common in sunny, urban areas with high vehicle traffic and is a major environmental concern for many large cities worldwide.

239. (A) Wetlands
The Ramsar Convention is an international treaty dedicated to the conservation and sustainable use of wetlands. Recognized for their critical importance as habitats for waterbirds and their role in maintaining water quality and flood control, these ecosystems are protected through a network of "Ramsar Sites." The convention encourages countries to develop national policies for the "wise use" of all their wetlands, ensuring these productive areas continue to provide essential ecological and economic benefits.

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240. (D) 1, 2 and 3
Species interactions are fundamental to ecosystem function and are categorized by their effects on the participants. Pollination is a key mutualistic interaction where both the plant and the animal benefit. Herbivory is a specific form of predation where animals feed on plant tissues. Symbiosis is a broad term that describes any close, long-term relationship between different species. All these interactions are essential for maintaining the biological complexity and stability of various ecological communities.

241. (B) Resistance
Resistance refers to the ability of a biological community or ecosystem to remain essentially

210. (A) 1 and 2 only
Soil porosity refers to the total volume of pore spaces in the soil, which determines its ability to hold air and water. Sandy soils have large pores, leading to high total porosity but low water retention as water drains away quickly. Clay soils actually have higher total porosity than sand, but because the pores are extremely small, they retain more water while having low permeability. Understanding these properties is essential for effective irrigation and land management.

211. (C) High numbers, large biomass, or significant effect on the community.
In community ecology, a dominant species is one that has a significant influence on the structure and character of its biological community. This dominance is often measured by the species' high numerical abundance, large total biomass, or its disproportionately large impact on environmental conditions. Dominant species often shape the habitat for other organisms and play a central role in energy flow and nutrient cycling, making them a defining feature of the ecosystem.

212. (D) Presence of multiple layers of epidermis and sunken stomata.
Xerophytes have evolved specific anatomical adaptations to survive in extremely dry conditions. One such feature is the presence of multiple epidermal layers, which provide a thick barrier against water loss. Additionally, many of these plants feature sunken stomata, which are located in deep pits on the leaf surface. This creates a small, humid microenvironment that further reduces the rate of transpiration, helping the plant conserve vital moisture during prolonged periods of drought.

213. (C) Seres
Seres, or seral stages, are the various intermediate communities that follow one another during the process of ecological succession. Each stage represents a temporary state where a specific group of species dominates the habitat before being replaced by the next community as environmental conditions change. These transitional phases eventually lead to a final, stable climax community that is in equilibrium with the local climate and soil, marking the end of the successional sequence.

214. (B) Intraspecific competition
Density-independent factors are environmental influences that affect a population's size regardless of its density, such as floods, wildfires, or extreme cold. In contrast, intraspecific competition is a density-dependent factor. As the number of individuals in a population increases, the competition for shared resources like food and space becomes more intense, leading to lower birth rates or higher mortality. This relationship helps regulate the population size based on the available resources in the habitat.

215. (D) Amount of inorganic nutrients present in the soil at a given time.
The standing state of an ecosystem refers to the total amount of inorganic nutrients, such as nitrogen, phosphorus, and calcium, present in the soil or water at a specific point in time. This is distinct from the standing crop, which measures the living biomass. The standing state represents the pool of available nutrients that can be taken up by producers to support growth and energy flow, serving as a critical indicator of the ecosystem's nutrient status.

216. (A) Niche
A niche describes the specific functional role and position of an organism within its ecological community. It encompasses not just where the organism lives, but also how it interacts with other species, what it eats, and how it uses the various resources in its environment. By defining an organism's unique "profession," the niche concept helps ecologists understand how multiple species can coexist in the same habitat by occupying different roles and minimizing direct competition.

217. (C) Forest resources
The Chipko movement is a world-renowned environmental campaign that started in the Indian Himalayas to protect forests from commercial logging. Villagers, particularly women, famously hugged trees to prevent them from being cut down, emphasizing the importance of forest resources for local livelihoods and environmental stability. This non-violent resistance became a powerful symbol for community-based conservation and the recognition of the essential link between people and the natural forests they depend on.

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218. (A) Being rich in iron and aluminum oxides and poor in nutrients.
Laterite soils are common in tropical regions with high rainfall and warm temperatures, which promote intense weathering of the parent rock. During this process, essential nutrients like silica and potassium are leached away, leaving behind high concentrations of iron and aluminum oxides. This gives the soil its characteristic reddish color. However, because most nutrients have been removed, laterite soils are generally poor in fertility and require careful management for agricultural use.

219. (D) Reducing the emission of greenhouse gases.
The Kyoto Protocol was a landmark international treaty aimed at addressing global climate change by setting legally binding targets for reducing greenhouse gas emissions. It focused primarily on industrial countries, requiring them to limit gases like carbon dioxide and methane that contribute to the enhanced greenhouse effect. Although its success was mixed, the protocol was a significant first step in global efforts to coordinate a response to rising average temperatures and their environmental impacts.

220. (B) P-2, Q-1, R-1, S-2
Life history strategies are categorized by trade-offs in reproduction and survival. The r-selection strategy features rapid development and the production of many small offspring, which is advantageous in unpredictable environments. In contrast, k-selection involves delayed reproduction and strong competitive ability, favoring survival in stable habitats. These strategies represent different evolutionary solutions for maximizing fitness under varying ecological conditions, reflecting how organisms invest their energy to ensure their population's long-term persistence and growth.

221. (C) It encompasses the variety of genes, species, and ecosystems.
Biodiversity is a comprehensive term that describes the entire variety of life on Earth across all biological levels. It includes genetic diversity within individual species, which allows them to adapt to changes; species diversity, representing the richness of different organisms in a community; and ecosystem diversity, which covers the diverse types of habitats and biological communities. This complex variety is essential for maintaining the health and resilience of the entire global biosphere.

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222. (D) J-shaped curve
A J-shaped curve represents exponential population growth, which occurs when a population expands rapidly without any immediate limiting factors. While this leads to a massive surge in population size, it is often followed by a dramatic crash once essential resources like food or space are exhausted. This pattern of growth and sudden decline is common in opportunistic species that rapidly colonize new environments but lack the mechanisms to stabilize their numbers sustainably.

223. (A) Serving area for research, education, and tourism compatible with conservation.
In a Biosphere Reserve, the buffer zone surrounds the strictly protected core area. Its primary purpose is to accommodate activities that are compatible with ecological protection, such as scientific research, environmental education, and low-impact tourism. By providing a transitional space, the buffer zone helps protect the sensitive core from direct human pressure while allowing for beneficial activities that support conservation goals and provide opportunities for people to learn about and appreciate nature.

224. (B) One organism inhibits the growth of another by releasing chemical substances.
Allelopathy is a specific type of biological interaction where an organism, usually a plant, releases chemical compounds into its environment that inhibit the growth, survival, or reproduction of other species. These allelochemicals can be released from roots, leaves, or decaying matter. This strategy helps the organism reduce competition from its neighbors, ensuring it has better access to resources like light and nutrients, and is common in many forest and agricultural ecosystems.

225. (B) Warm and moist environments with ample oxygen.
Decomposition is a biological process driven by microorganisms like bacteria and fungi, which thrive in specific environmental conditions. It proceeds fastest in warm and moist environments where there is plenty of oxygen.

These conditions optimize the metabolic activity of the decomposers, allowing them to rapidly break down organic matter and recycle nutrients. In contrast, extreme cold, dryness, or anaerobic conditions significantly slow down this essential ecosystem function, leading to the accumulation of organic material.

226. (A) 1973
Project Tiger was launched by the Government of India in 1973 to ensure a viable population of the national animal in its natural habitats. The program focuses on establishing protected areas called Tiger Reserves and managing them specifically for conservation. By protecting the tiger, an apex predator, the initiative also safeguards entire ecosystems and numerous other species. Project Tiger has become one of the most successful wildlife conservation efforts globally, significantly increasing tiger numbers.

227. (C) The physical condition of the soil in relation to its suitability for plant growth.
Soil tilth refers to the physical state of the soil as it relates to how well it supports plant growth and how easily it can be cultivated. It encompasses several factors, including soil structure, drainage, aeration, and moisture content. Good tilth means the soil is loose and crumbly, allowing for easy root penetration and water movement. Maintaining healthy tilth through proper management is essential for successful agriculture and sustainable land use.

228. (D) Global warming
Global warming is the long-term increase in the Earth's average surface temperature, primarily caused by the buildup of greenhouse gases like carbon dioxide and methane in the atmosphere. These gases trap heat from the sun that would otherwise radiate back into space, creating an enhanced greenhouse effect. This warming leads to various environmental impacts, such as melting glaciers, rising sea levels, and altered weather patterns, posing significant challenges for natural ecosystems and human civilization.

229. (C) A hardy, unpalatable, or thorny weed.
On an overgrazed rangeland, palatable and nutritious grasses are often consumed first by livestock, leading to their decline. Consequently, hardy and unpalatable plant species, such as thorny weeds or those containing bitter chemicals, tend to increase in abundance because they are avoided by grazers. The presence and dominance of these undesirable species serve as a clear plant indicator that the land has been subjected to excessive grazing pressure and needs management intervention.

230. (B) Rio Earth Summit, 1992
The Convention on Biological Diversity is a major international treaty that was opened for signature at the United Nations Conference on Environment and Development, also known as the Rio Earth Summit, in 1992. The convention aims to conserve biodiversity, promote its sustainable use, and ensure the fair and equitable sharing of benefits arising from genetic resources. It represents a global commitment to protecting Earth's biological variety for the benefit of both current and future generations.

231. (D) Age structure
Age structure describes the relative proportion of individuals in different age groups within a population, typically categorized as pre-reproductive, reproductive, and post-reproductive. This characteristic is a vital indicator of a population's health and its potential for future growth or decline. For example, a population with many young individuals has high potential for rapid expansion, while one with many elderly individuals may eventually face a decline in size, helping ecologists predict population trends.

232. (A) Phosphorus cycle
A sedimentary nutrient cycle is one where the primary reservoir of the element is found in Earth's crust rather than in the atmosphere. The phosphorus cycle is a classic example because phosphorus does not have a significant gaseous phase; it is stored in rocks and mineral deposits. It enters the biosphere through weathering and is cycled through living organisms before eventually returning to soil and sediments, making its movement much slower than gaseous cycles.

233. (C) Profundal zone
In a deep lake, the profundal zone is the dark, bottom area where sunlight cannot penetrate. Because there is no light, photosynthesis

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water runoff and helps prevent soil erosion. By managing the movement of water, terracing also improves moisture retention in the soil. This traditional method allows people to farm effectively on steep land while protecting the valuable topsoil from being washed away.

265. (C) Species will shift their ranges towards the poles and higher altitudes.
As global temperatures rise due to warming, many species are likely to shift their geographic ranges in search of cooler, suitable climates. This typically involves moving toward the North and South Poles or to higher altitudes on mountains. While some species may successfully adapt to new locations, others may face extinction if they cannot move fast enough or if they run out of suitable habitats, significantly altering the composition and balance of ecosystems around the world.

266. (A) Heliophyte
A heliophyte is a plant that is specifically adapted to thrive in environments with high light intensity and full exposure to the sun. These plants have developed physiological and anatomical features, such as high photosynthetic rates and thick leaves, to make the most of abundant solar energy. They are typically found in open areas like meadows, deserts, and the top layer of a forest canopy, where they can grow rapidly compared to shade-loving plants.

267. (D) Starts in an area that already has soil and some life forms.
Secondary succession is the process of community development that occurs in an area where an existing community has been removed by a disturbance but the soil remains. Unlike primary succession, which starts on bare rock, secondary succession benefits from the presence of nutrients and biological remains like seeds or roots. This allows the process to happen much more quickly, as life can re-emerge and colonize the area more easily, eventually leading back to a stable community.

268. (B) The birth rate.
Natality is a key population-level characteristic that refers to the birth rate of a specific group of organisms within a given period. It is usually expressed as the number of births per thousand individuals. Natality, along with mortality, immigration, and emigration, determines how a population size changes over time. Understanding birth rates helps ecologists predict future population trends and assess the reproductive health and growth potential of various species in their natural habitats.

269. (C) The atmosphere and oceans.
The carbon cycle features major reservoirs where carbon is stored as it moves through the environment. The atmosphere contains carbon dioxide, which is used by plants for photosynthesis. However, the oceans represent an even larger reservoir, storing vast amounts of dissolved carbon. These two reservoirs are in constant exchange with each other and with living organisms. Understanding these pools is essential for studying climate change, as human activities are shifting carbon from geological stores into these active reservoirs.

270. (B) P-3, Q-4, R-1, S-2
Species interactions are diverse: mutualism, like mycorrhizae, benefits both parties; parasitism, such as tapeworms, harms the host; commensalism, like orchids on trees, helps one while leaving the other unaffected; and competition involves species vying for limited resources like water. Matching these interactions with real-world examples illustrates the complex relationships that shape biological communities. These interactions drive the evolution of species and determine the overall structure and stability of ecosystems in nature.

271. (A) Tundra
While India has a wide variety of biomes, ranging from tropical rainforests and deserts to temperate forests, the tundra as a major latitudinal biome is not found in the country. Tundra is characterized by extremely cold, treeless landscapes in the high northern latitudes. Although India has high-altitude alpine regions in the Himalayas that share some characteristics with tundra, the actual global tundra biome is located far to the north, primarily in the Arctic regions of the world.

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272. (B) To provide a safe haven for wildlife through in-situ conservation.
The primary objective of establishing National Parks and Wildlife Sanctuaries is to protect

unchanged when subjected to a disturbance. A highly resistant community can withstand environmental stresses, such as fire or storms, without significant shifts in its species composition or structure. This attribute is a key component of ecological stability, as it allows the community to maintain its functional roles and overall integrity despite the constant pressures and fluctuations of the surrounding environment.

242. (A) Heliophytes
Heliophytes are specialized plants that are adapted to grow in conditions with high light intensity and full sunlight. These plants typically have high photosynthetic rates and often possess physical features like thick leaves or a protective waxy cuticle to handle intense solar radiation. Unlike sciophytes, which prefer shade, heliophytes require abundant light to thrive and are commonly found in open habitats like grasslands, deserts, or the uppermost canopy of a forest.

243. (C) Species diversity
The Shannon-Wiener index is a mathematical formula used in ecology to measure the diversity of species within a community. It accounts for both species richness, which is the total number of species, and evenness, which describes how equally individuals are distributed among those species. By providing a single numerical value, this index allows scientists to compare the biological complexity of different habitats and track changes in community composition over time or across regions.

244. (D) Eutrophication
Eutrophication is the process of nutrient enrichment in a water body, which can occur naturally over time or be accelerated by human activities like agricultural runoff. This excess of nutrients, particularly nitrogen and phosphorus, triggers an explosion of algal growth. As the algae die and decompose, they use up the dissolved oxygen in the water, which can lead to the death of other aquatic organisms, severely disrupting the health and balance of the entire ecosystem.

245. (C) The physical location or environment where it lives.
An organism's habitat is the specific physical place or environment where it naturally occurs. It provides the essential conditions—such as food, water, shelter, and climate—that the organism needs to survive and reproduce. Think of a habitat as the "address" of a species, whether it is a forest, a desert, or a pond. Understanding habitats is crucial for conservation, as protecting the physical environment is the first step in preserving the species that live there.

246. (B) A Gene Bank
Ex-situ conservation involves the protection of genetic material, seeds, or individuals outside of their natural habitats. A gene bank is a classic example of this approach, where genetic resources like seeds or plant tissues are stored in controlled conditions to preserve them for the future. Unlike in-situ methods like National Parks, which protect species in the wild, gene banks provide a secure backup against extinction and a source of material for research and breeding programs.

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247. (D) Weathered parent rock material.
The C-horizon is a soil layer that consists of partially weathered parent material, which is the original rock or sediment from which the soil is developing. It is located beneath the more biologically active upper horizons and above the unweathered bedrock. While it contains some mineral fragments, the C-horizon has undergone very little chemical or physical change compared to the topsoil, representing an early stage in the complex process of soil formation and development.

248. (A) The veterinary use of the drug diclofenac, which is toxic to vultures.
Vulture populations in India faced a catastrophic decline primarily due to the widespread veterinary use of diclofenac, an anti-inflammatory drug used in cattle. When vultures fed on the carcasses of treated livestock, they suffered from acute kidney failure, leading to death. This loss of vultures had significant ecological and public health impacts, as they are essential scavengers. The eventual ban on diclofenac in veterinary medicine was a critical step in efforts to save these birds.

249. (C) Methane (CH4)
Methane is a potent greenhouse gas that is much more effective at trapping heat in the atmosphere than carbon dioxide over a short period. It is

produced through various natural and human activities, including the decomposition of organic matter in wetlands, livestock digestion, and the extraction of fossil fuels. As its concentration increases, methane contributes significantly to global warming and climate change, making its management a key target for international environmental policies and conservation efforts.

250. (A) Both A and R are true and R is the correct explanation of A.
A species' fundamental niche represents the full range of conditions it could potentially occupy, but its realized niche is often smaller in nature. This reduction occurs because biological interactions like competition for resources, predation, and parasitism prevent the species from using every possible habitat and resource. These ecological pressures restrict the species to a narrower set of conditions where it can successfully survive and reproduce despite the presence of other organisms.

251. (D) Resilience
Resilience is the ability of an ecosystem or community to return to its original state quickly after being disturbed by an event like a fire, flood, or human intervention. A resilient system can absorb changes and recover its functional structure and species composition relatively fast. This attribute is essential for the long-term survival of biological communities in a changing environment, as it determines how well they can bounce back from sudden stresses and maintain their ecological health.

252. (B) The pattern of survival and reproduction events typical for a member of the species.
A life history strategy refers to the specific suite of traits that an organism has evolved to maximize its lifetime reproductive success. This includes the timing and frequency of reproduction, the number and size of offspring, and the overall lifespan. These strategies are shaped by the environmental conditions and trade-offs that the species faces, such as the choice between producing many small offspring or a few high-quality ones to ensure survival in their specific habitat.

253. (C) Tertiary consumers
In an ecosystem, the amount of available energy decreases at each successive trophic level because energy is lost as heat during metabolic processes. This means that producers have the most energy, followed by primary and secondary consumers. Tertiary consumers, which are at the top of the food chain, have the least amount of energy available to them. This energy loss is the reason why there are fewer top predators in an ecosystem compared to the number of organisms at lower levels.

254. (D) Ammonification (Mineralization)
Ammonification, also known as mineralization, is the process where decomposers like bacteria and fungi break down organic nitrogen from dead plants and animals into inorganic ammonia. This step is vital in the nitrogen cycle because it converts nitrogen into a form that can eventually be turned into nitrates by other bacteria for use by plants. By recycling nitrogen from organic matter, ammonification ensures a continuous supply of this essential nutrient for the growth of all living organisms.

255. (A) Tundra
The tundra is a treeless terrestrial biome characterized by extremely low temperatures, very little precipitation, and a permanently frozen subsoil called permafrost. Because of the harsh conditions and short growing season, only small, hardy plants like mosses, lichens, and dwarf shrubs can survive. The absence of large trees and the dominance of specialized vegetation make the tundra a unique and fragile ecosystem that is highly adapted to the severe, cold climate of the high northern latitudes.

256. (B) Invasive species
An invasive species is an organism that is introduced into a new environment where it does not naturally occur and subsequently causes ecological or economic harm. Because they often lack natural predators and competitors in their new home, invasive species can multiply rapidly and outcompete native plants and animals for resources. This can lead to the displacement or extinction of local species and significantly disrupt the balance of the ecosystem, posing a major threat to global biodiversity.

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257. (B) Barasingha (Swamp Deer)
Kanha National Park in Madhya Pradesh is world-famous for its successful conservation of the Barasingha, or swamp deer. The park played a critical role in bringing this species back from the brink of extinction through dedicated habitat management and protection efforts. Today, it remains the only place where this specific subspecies can be found in the wild. The Barasingha serves as an important mascot for the park and a symbol of the success of targeted wildlife conservation in India.

258. (A) The availability of nutrients to plants
Soil pH is a critical factor that influences the chemical form and availability of essential nutrients to plants. In very acidic or highly alkaline soils, many nutrients like phosphorus or iron may become chemically "locked" and unavailable for root uptake, even if they are present in the soil. Most plants prefer a slightly acidic to neutral pH range where nutrient availability is maximized. Understanding soil pH is essential for proper fertilizer use and successful agricultural and horticultural practices.

259. (C) Sulfur dioxide
Using coal as a fuel for power generation releases significant amounts of sulfur dioxide into the atmosphere. Coal often contains sulfur impurities, which combine with oxygen during combustion. This sulfur dioxide is a major air pollutant that can cause respiratory issues in humans and, when mixed with water vapor, forms acid rain. Acid rain can damage forests, aquatic life, and human-made structures, making sulfur dioxide emissions a major environmental concern associated with coal-fired energy production worldwide.

260. (A) 4, 3, 2, 1
The global environmental movement has been shaped by several key summits and protocols. It began with the Stockholm Conference in 1972, which brought environmental issues to the international stage. This was followed by the Montreal Protocol in 1987 to protect the ozone layer, the Rio Earth Summit in 1992 to focus on biodiversity, and the Kyoto Protocol in 1997 to address greenhouse gas emissions. These events represent the evolution of international cooperation toward protecting the global environment.

261. (C) A species expands its niche in response to the removal of a competitor.
Competitive release occurs when a species is able to expand its ecological niche and use a wider range of resources because its competitors have been removed or are absent. In many communities, species are restricted to a smaller "realized niche" because they have to compete with others. When those competitors are gone, the species can occupy more of its potential "fundamental niche," demonstrating how biological interactions like competition normally limit the distribution and resource use of organisms.

262. (B) The flow of energy is multidirectional, from consumers back to producers.
In an ecosystem, the flow of energy is strictly unidirectional, moving from producers to various levels of consumers and eventually being lost as heat. While nutrients are recycled back to producers through decomposition, energy never flows back to them. A food web realistically represents these complex pathways, showing that many organisms occupy multiple trophic levels, but the energy always moves in one direction through the biological community, never returning to its source.

263. (D) High number of endemic species and significant habitat loss.
The Western Ghats, Sri Lanka, and the Indo-Burma regions are recognized as global biodiversity hotspots because they contain an exceptional number of species found nowhere else on Earth. However, these areas are also characterized by significant habitat loss due to human activities like logging and agriculture. Protecting these hotspots is a global priority because they contain a vast portion of Earth's unique biological variety that is also under the most immediate and severe threat.

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264. (A) Terrace cultivation
Terrace cultivation is an agricultural practice used on hilly or mountainous terrain where level platforms, or benches, are cut into the slopes. This technique creates a series of flat areas for growing crops, which significantly slows down

202. (A) Hibernation
Hibernation is a significant physiological adaptation that allows certain animals to survive extreme cold and food scarcity during winter. During this state, an animal's metabolic rate, heart rate, and body temperature decrease dramatically to conserve energy. This allows the organism to survive for months on stored body fat without needing to find food. Unlike physical traits like thick fur, hibernation involves deep changes in internal biological processes to endure harsh seasonal conditions.

203. (D) Dispersion
Dispersion refers to the spatial pattern of individuals within a population's geographic range. Common patterns include clumped, where individuals are grouped together; uniform, where they are evenly spaced; and random, where there is no predictable pattern. These patterns are influenced by resource distribution, social behaviors, and environmental factors. Understanding dispersion helps ecologists learn about how individuals interact with each other and their habitat, providing insights into population dynamics and resource utilization.

204. (B) Volcanic eruptions
Volcanic eruptions are a major natural source of sulfur dioxide released into the atmosphere. During an eruption, huge quantities of sulfur-containing gases are emitted from deep within the Earth's crust. This sulfur can eventually return to the surface as acid rain or be incorporated into sedimentary rocks over geological time. These events play a significant role in the global sulfur cycle, demonstrating how geological processes can influence the chemical composition of the atmosphere and terrestrial environments.

205. (C) Resource partitioning
Resource partitioning is an ecological strategy that allows similar species to coexist in the same habitat by dividing resources. In the case of warblers living in a single tree, different species may feed at different heights or on different branches. By specializing in these distinct micro-habitats, they avoid direct competition for the same insects. This reduction in niche overlap enables multiple species to share a limited environment while maintaining stable population sizes.

206. (D) Mediterranean (Chaparral)
The Mediterranean biome, also known as chaparral, is characterized by a unique climate of hot, dry summers and cool, moist winters. The vegetation is dominated by dense, evergreen shrubs that have evolved specific adaptations to survive periodic fires, such as the ability to resprout from roots or produce fire-activated seeds. This biome is found in coastal regions with Mediterranean-style climates, supporting a specialized community of plants and animals adapted to seasonal drought and fire.

207. (A) Reduce the speed of water runoff and prevent soil erosion.
Soil conservation practices like contour farming and strip cropping are designed to slow down the movement of water across the land surface. By creating barriers or altering the direction of flow, these methods reduce the speed of runoff, which significantly minimizes the amount of topsoil being washed away. These techniques are essential for maintaining land productivity and preventing long-term degradation, especially on sloped terrain where erosion risk is naturally higher.

208. (B) September 16th
International Ozone Day is celebrated annually on September sixteenth to commemorate the signing of the Montreal Protocol in 1987. The day aims to raise global awareness about the importance of the ozone layer and the need for continued international cooperation to protect it. By celebrating this occasion, the world recognizes the successful efforts to phase out ozone-depleting substances and emphasizes the ongoing responsibility to safeguard Earth's atmosphere for future generations.

209. (B) Biosphere reserve
In-situ conservation focuses on protecting species and their genetic diversity within their natural habitats. A Biosphere Reserve is a primary example of this approach, as it aims to preserve entire ecosystems while allowing for sustainable human use and scientific research. In contrast, botanical gardens and zoos are ex-situ methods where species are kept outside their original environment. In-situ conservation is vital because it maintains the complex ecological interactions necessary for long-term species survival.

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species and their ecosystems within their natural habitats, known as in-situ conservation. These protected areas provide a safe environment free from major human disturbances like hunting and industrial development. By preserving the original environment, these areas ensure that wild animals and plants can continue to live, reproduce, and interact naturally, maintaining the biological variety and ecological processes essential for the health of our planet.

273. (B) Soil Taxonomy
Soil taxonomy is a systematic method of classifying soils based on their measurable properties and the stages of their development. This approach considers various factors, including the presence of specific layers called diagnostic horizons, soil chemistry, and physical structure. By using a standard scientific framework, soil taxonomy allows researchers and farmers around the world to communicate clearly about soil types and predict how they will respond to different agricultural practices or environmental changes.

274. (A) The Bhopal Gas Tragedy
The Environment Protection Act of 1986 was enacted in India shortly after the Bhopal Gas Tragedy, one of the world's worst industrial disasters. This tragedy highlighted the urgent need for comprehensive national laws to manage environmental risks and ensure industrial safety. The act provides the government with broad powers to coordinate environmental protection efforts, set pollution standards, and take immediate action against activities that threaten public health or the environment, marking a significant shift in national policy.

275. (C) The exploration of biodiversity for commercially valuable genetic and biochemical resources.
Bioprospecting is the process of searching for and discovering new biological resources, such as genes or chemical compounds, that have commercial value in industries like medicine and agriculture. Scientists explore diverse environments, including forests and oceans, to find organisms with unique properties. While it can lead to important discoveries, bioprospecting must be managed carefully and ethically to ensure that local communities and countries benefit fairly from the use of their native biological resources.

276. (D) The external appearance or look of the community.
In ecology, physiognomy refers to the general physical appearance or "look" of a biological community, which is determined by the dominant growth forms of its vegetation. For example, the physiognomy of a forest is defined by large trees and a closed canopy, while a grassland appears as an open area dominated by grasses. This external structure reflects the community's adaptation to its environment and provides a quick way for ecologists to categorize and compare different types of ecosystems.

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277. (C) Mangrove plants (halophytes)
Vivipary is a specialized reproductive adaptation found in many mangrove plants, where seeds germinate while they are still attached to the parent tree. The developing seedling grows into a small plant before falling off into the water or mud below. This gives the plant a better chance of surviving in the harsh, waterlogged, and saline environment of coastal marshes, where ordinary seeds would likely drown or be unable to take root in the shifting soil.

278. (B) Disease and parasitism
Density-dependent factors are biological influences that limit population growth more strongly as the population becomes larger and more crowded. Disease and parasitism are classic examples, as pathogens can spread much more easily when individuals live in close proximity to each other. This increased pressure can lead to higher mortality rates or lower reproductive success, helping to regulate the population size and prevent it from exceeding the carrying capacity of its environment in a sustainable way.

279. (D) Fragmentation
Fragmentation is the initial step in the process of decomposition, where large pieces of dead organic matter, or detritus, are broken down into smaller particles. This physical breakdown is often carried out by soil animals like earthworms and various insects. By increasing the surface area of the organic material, fragmentation makes it much easier for microbial decomposers like bacteria and fungi to further break down the

295. (D) A species whose conservation indirectly protects many other species within its habitat.
An umbrella species is one that has large habitat requirements or a broad ecological niche, so that protecting it automatically protects many other species that share the same environment. Conservation efforts focused on an umbrella species, such as a tiger or a grizzly bear, involve preserving vast areas of natural habitat. This large-scale protection benefits the entire biological community, making the umbrella species approach an efficient way to conserve broad biodiversity and maintain healthy, functioning ecosystems.

296. (A) Savanna and Chaparral
Biomes like the savanna and chaparral are characterized by environments where periodic fires are a natural and recurring part of the ecological cycle. Many plants in these biomes have evolved specific fire-adapted features, such as thick, heat-resistant bark or cones that only release their seeds after being exposed to high temperatures. These adaptations allow the vegetation to survive and even thrive after a fire, which can clear out competing plants and return essential nutrients to the soil.

297. (C) Succession
Succession is the orderly, directional, and predictable process of community change that occurs in an ecosystem over time. It begins with the colonization of an area by pioneer species and proceeds through several intermediate seral stages. Each stage modifies the environment, paving the way for the next group of species. This process eventually leads to a final, stable climax community that is in equilibrium with the local climate, marking the culmination of these gradual biological and environmental shifts.

298. (A) The number of offspring and the amount of parental investment.
The trade-off between the number of offspring and parental investment is a central concept in life history strategies. Species following an r-selection strategy produce many small offspring with very little care, which is successful in unstable environments. In contrast, k-selected species produce a few large offspring and invest heavily in their care to ensure they can compete effectively in stable habitats. These different strategies represent evolutionary balances that maximize the long-term reproductive success of different types of organisms.

299. (D) Unidirectional
In an ecosystem, the flow of energy is strictly unidirectional, meaning it moves in only one direction from producers to consumers. Energy is captured from the sun by plants and then passed along the food chain as organisms are eaten. At each step, a significant amount of energy is lost as heat through metabolic processes and respiration. Unlike nutrients, which are recycled back to producers through decomposition, energy is never reused and eventually dissipates from the biological system.

300. (B) High endemism and high threat level
The concept of biodiversity hotspots focuses conservation efforts on specific regions that are home to an exceptionally high number of endemic species—those found nowhere else on Earth. To be classified as a hotspot, a region must also be under a high level of threat, having lost at least seventy percent of its original natural habitat. By prioritizing these areas, conservationists aim to protect the most unique and vulnerable biological variety on the planet before it is lost forever.

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remains largely unchanged over long periods. Unlike earlier successional stages, the climax community is dominated by long-lived, highly competitive species that are well-adapted to the stable environmental conditions, representing the culmination of the directional changes in the successional process.

288. (B) The carrying capacity of the environment.
In the logistic growth equation, the variable 'K' represents the carrying capacity, which is the maximum population size that an environment can sustainably support given the available resources like food, water, and space. As the population size approaches this limit, the growth rate slows down, eventually reaching zero when the population reaches 'K.' This concept is fundamental for understanding how environmental resistance regulates population growth and maintains a balance between species and their habitats in nature.

289. (B) Are not preyed upon by other animals in the food web.
Top carnivores, also known as apex predators, occupy the highest trophic level in a food web. These organisms, such as lions or eagles, feed on various other consumers but have no natural predators themselves within their ecosystem. Because they are at the end of the energy flow, their populations are usually smaller than those at lower levels. Top carnivores play a vital role in regulating the populations of other species and maintaining the overall balance and health of their environment.

290. (A) Charles Elton
The concept of ecological pyramids was first introduced by British ecologist Charles Elton in the late 1920s. He observed that in many ecosystems, there are far more organisms and biomass at the lower trophic levels than at the higher ones, creating a pyramid-like structure. These diagrams, sometimes called Eltonian pyramids, provide a visual way to represent the distribution of numbers, biomass, or energy across the different levels of a food chain, helping ecologists study ecosystem organization.

291. (C) A fungus and the roots of higher plants.
Mycorrhiza is a widespread mutualistic association between specialized fungi and the roots of most vascular plants. In this symbiotic relationship, the fungus helps the plant absorb essential nutrients like phosphorus from the soil more efficiently, while the plant provides the fungus with organic food produced through photosynthesis. This partnership is vital for the health and growth of many plants, especially in nutrient-poor soils, and plays a significant role in the overall productivity and stability of terrestrial ecosystems.

292. (D) Mangrove Ecosystem
The Sunderbans is a massive, world-famous mangrove ecosystem located in the delta of the Ganga and Brahmaputra rivers. It is characterized by its salt-tolerant trees, complex network of tidal waterways, and unique wildlife, including the Royal Bengal Tiger. This vast wetland provides essential coastal protection against storms and serves as a highly productive nursery for many aquatic species. The Sunderbans is a critical biological region that showcases the specialized adaptations of life in a tidal, saline environment.

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293. (C) Texture, structure, and composition
The physical and chemical properties of a soil are determined by its texture, which is the proportion of different particle sizes; its structure, or how those particles are arranged; and its chemical composition. Together, these features influence how well the soil can hold water, circulate air, and provide nutrients to plants. Understanding these fundamental characteristics is essential for assessing land productivity, choosing suitable crops, and managing the soil sustainably for both agriculture and the health of natural ecosystems.

294. (B) Long-term shifts in temperatures and weather patterns, including warming, cooling, and changes in precipitation.
Climate change is a broad term that encompasses significant, long-term shifts in Earth's overall weather patterns. While it is often used interchangeably with global warming, it also includes changes in rainfall, wind patterns, and the frequency of extreme events like droughts or floods. These shifts can be caused by both natural processes and human activities. Understanding the full scope of climate change is essential for predicting its broad impacts on ecosystems, agriculture, and human societies across the entire planet.

28. The plant Cannabis sativa is well-known in ethnobotany for all of the following uses EXCEPT:
(A) A source of strong fibres (hemp).
(B) A source of edible oil from its seeds.
(C) A source of psychoactive compounds.
(D) A primary source of rubber.

29. Given below are two statements.
Statement I: Emblica officinalis, commonly known as Amla, is highly valued in Ayurveda for its high Vitamin C content.
Statement II: The fruit of Emblica officinalis is traditionally used as a laxative and for treating jaundice.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

30. The dried flower buds of which plant are used as the spice 'clove'?
(A) Eugenia jambolana
(B) Piper nigrum
(C) Eugenia aromatica
(D) Mentha arvensis

31. Holarrhena antidysenterica is ethnobotanically significant, as its name suggests, for the treatment of:
(A) Skin diseases
(B) Heart ailments
(C) Bronchial inflammation
(D) Dysentery

32. The seeds of Jatropha curcas have gained significant attention for their potential use in:
(A) The production of biodiesel.
(B) The production of a coffee substitute.
(C) A primary food source for diabetic patients.
(D) Manufacturing high-quality paper.

33. The dye 'henna', used in ethnocosmetics for body art, is obtained from which plant?
(A) Azadirachta indica
(B) Lawsonia inermis
(C) Butea monosperma
(D) Santalum album

34. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Ocimum sanctum (Tulsi) is considered a sacred plant in many Indian households.
Reason (R): It is widely used in Ayurvedic and traditional medicine for its adaptogenic and antimicrobial properties.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

35. The 'King of Spices', used globally and in traditional medicine as a biostimulant, is derived from the dried fruits of:
(A) Zingiber officinale
(B) Eugenia aromatica
(C) Piper nigrum
(D) Allium sativum

36. Which part of the Pterocarpus marsupium tree is traditionally used to make tumblers for diabetic patients, who would drink water stored in them?
(A) The leaves
(B) The flowers
(C) The root bark
(D) The heartwood

37. The milky latex obtained from the unripe capsules of Papaver somniferum is the source of:
(A) Cocaine
(B) Quinine
(C) Digitalis
(D) Opium

38. Consider the following statements regarding Rauvolfia serpentina:
1. It is the primary commercial source of natural rubber.
2. Its roots are used to extract the alkaloid reserpine.
3. Reserpine is traditionally used to treat high blood pressure and insanity.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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CHAPTER 07
Ethnobotany and Applied Botany

1. Which of the following best defines Ethnobotany?
(A) The study of the physiological processes of economically important plants.
(B) The scientific study of the relationships that exist between peoples and plants.
(C) The classification of plants based solely on their genetic makeup.
(D) The commercial cultivation of medicinal plants for pharmaceutical industries.

2. What is the primary focus of Archaeoethnobotany?
(A) Analysis of plant remains from archaeological sites.
(B) Study of theoretical futuristic human-plant interactions.
(C) Modern-day usage of plants in diverse tribal medicines.
(D) Linguistic origins of plant names in ancient civilizations.

3. Given below are two statements.
Statement I: Ethnomedicine is concerned with the traditional medicinal uses of plants by various cultures.
Statement II: Ethnopharmacology is the scientific study of the pharmacological properties of substances used in traditional medicine.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

4. The sub-discipline of ethnobotany that deals with the traditional knowledge of treating bone fractures using plants is known as:
(A) Ethnopaediatrics
(B) Ethno-gynaecology
(C) Ethno-ophthalmology
(D) Ethno-orthopaedics

5. Which of the following is NOT considered a sub-discipline of ethnobotany?
(A) Ethnotaxonomy
(B) Ethnolinguistics
(C) Phytochemistry
(D) Ethnocosmetics

6. A researcher studying how a specific tribe classifies the plants in their local environment is engaged in which field?
(A) Ethnoecology
(B) Ethnotaxonomy
(C) Ethnopharmacology
(D) Ethnomusicology

7. Match List I with List II and select the correct answer using the codes given below.
List I: (Sub-discipline)
P. Ethno-gynaecology
Q. Ethnotoxicology
R. Ethnopaediatrics
S. Ethno-ophthalmology
List II: (Area of Study)
1. Traditional knowledge of plant-based poisons
2. Traditional remedies for children's diseases
3. Traditional treatments for eye ailments
4. Traditional knowledge related to childbirth and women's health
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-3, S-1

8. What is the central theme of Ethnoecology?
(A) The study of traditional perspectives and management of ecological relationships.
(B) The study of the chemical composition of ethnobotanically important plants.
(C) The specialized use of plants in creating traditional musical instruments.
(D) The analytical study of folk tales and myths related to local plant life.

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matter chemically, eventually releasing essential nutrients back into the ecosystem.

280. (A) The broadest possible niche that a species could potentially occupy.
The fundamental niche represents the entire range of environmental conditions and resources a species could potentially use if there were no biological constraints like competition or predation. It reflects the species' physiological tolerances and absolute requirements for survival. In nature, however, species are usually restricted to a narrower "realized niche" because their interactions with other organisms prevent them from occupying every possible part of their environment, highlighting the difference between potential and actual distribution.

281. (C) Ecosystem management approach
The ecosystem management approach is a broad conservation strategy that focuses on protecting entire biological communities and their physical environments rather than just individual species. By preserving large blocks of habitat, this approach ensures that the complex interactions and essential ecological processes, such as nutrient cycling and energy flow, continue to function. This holistic method is effective because it indirectly protects many species at once and maintains the overall health and resilience of the landscape.

282. (A) Eluviation
The A horizon of the soil, or topsoil, is known as the zone of eluviation because water moving down through the soil washes away minerals and fine particles from this layer. This process of leaching can remove essential nutrients and alter the soil's appearance, often leaving the horizon lighter in color. The materials removed from the A horizon are eventually deposited in the B horizon below, contributing to the development of the distinct vertical layers seen in a soil profile.

283. (D) Carbon monoxide (CO)
Carbon monoxide is a colorless and odorless primary air pollutant produced by the incomplete combustion of fossil fuels, particularly in vehicles and industrial processes. When there is not enough oxygen during burning, carbon is not fully converted into carbon dioxide, resulting in carbon monoxide instead. This gas is highly toxic to humans because it reduces the blood's ability to carry oxygen. Its presence in the atmosphere is a major indicator of pollution from traffic and industrial activity.

284. (B) Co-extinctions
The "Evil Quartet" is a term used to describe the four major drivers of biodiversity loss: habitat destruction, overexploitation, invasive species, and co-extinctions. Co-extinction occurs when the extinction of one species leads to the decline and eventual extinction of another that depends on it, such as a specialized pollinator or a parasite. This phenomenon illustrates the complex interconnectedness of life, where the loss of one link in the ecosystem can trigger a chain reaction of further biological decline.

285. (D) 1, 2 and 3
Conservation biology is based on several core principles that guide efforts to protect biodiversity. It recognizes that evolutionary processes are the foundation of biological variety and must be allowed to continue. It also emphasizes the importance of maintaining ecological complexity for stability and acknowledges that all species have an intrinsic value regardless of their use to humans. These principles provide a scientific and ethical framework for managing the natural world and ensuring the survival of life on Earth.

286. (D) Phenotypic plasticity
Phenotypic plasticity is the ability of an organism to change its physical, physiological, or anatomical characteristics in response to variations in its environment. For example, a plant might grow larger leaves in the shade or change its flowering time based on temperature. This flexibility allows individuals to survive and reproduce in diverse or changing conditions without needing genetic mutations. It is an important way that organisms adapt to their immediate surroundings and cope with environmental fluctuations during their lifetime.

287. (A) It is in equilibrium with the environment and exhibits long-term stability.
A climax community represents the final, relatively stable stage of ecological succession in a particular region. At this point, the community has reached a state of equilibrium with the local climate and soil, and its species composition

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instruments.
(D) A plant species domesticated by tribal people for food.

19. Which of the following systems of medicine is based on the concept of 'tridoshas' (Vata, Pitta, Kapha)?
(A) Allopathic system
(B) Homeopathic system
(C) Ayurvedic system
(D) Unani system

20. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Tribal communities often play a significant role in wildlife protection.
Reason (R): Their cultural beliefs, including totems and sacred groves, often lead to the conservation of specific habitats and species.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

21. The process by which tribal people have selected and cultivated wild plants over generations, leading to new varieties, is known as:
(A) Plant domestication
(B) Phytoremediation
(C) Cryopreservation
(D) Somatic hybridization

22. A folktale that explains the origin of a sacred plant used for healing is a part of the study of ethnobotany because it:
(A) Provides a scientifically accurate description of the plant's chemistry.
(B) Offers a method for mass cultivation of the plant.
(C) Reveals the cultural significance and context of the plant's use.
(D) Is the only source of information about the plant's existence.

23. Which of the following plants is ethnobotanically known for its potent cardiotonic and neurotoxic alkaloids, often used with extreme caution in traditional medicine?
(A) Aconitum napellus
(B) Aloe vera
(C) Allium cepa
(D) Azadirachta indica

24. Consider the following statements about plant usage:
1. The Allopathic system of medicine exclusively uses synthetic compounds and never derives drugs from plants.
2. Folklore and folktales can be valuable sources for identifying plants with potential medicinal properties.
3. The use of plants in similes and metaphors reflects the deep cultural integration of the plant world.
Which of the above statement(s) is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

25. The ethnobotanical importance of Allium sativum is primarily associated with its use as:
(A) A primary source of strong textile fibre.
(B) A high-quality timber-yielding plant.
(C) A medicine for heart and infection.
(D) A psychoactive substance in rituals.

26. Which alkaloid, derived from Atropa belladonna, is used in ophthalmology to dilate the pupils?
(A) Atropine
(B) Quinine
(C) Reserpine
(D) Morphine

27. Match List I with List II and select the correct answer using the codes given below.
List I: (Plant)
P. Aloe vera
Q. Azadirachta indica
R. Butea monosperma
S. Cassia fistula
List II: (Common Ethnobotanical Association)
1. Flame of the Forest
2. Indian Laburnum, known as a purgative
3. Neem, used in skin care and as a pesticide
4. Soothing gel for skin ailments
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-3, R-4, S-1

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(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

51. To treat amoebic dysentery, a decoction from the bark of which plant is traditionally recommended?
(A) Terminalia arjuna
(B) Pterocarpus marsupium
(C) Holarrhena antidysenterica
(D) Jatropha curcas

52. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Azadirachta indica (Neem) is widely used in traditional remedies for skin diseases.
Reason (R): The leaves and oil of Neem possess strong antibacterial and antifungal properties.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

53. For the traditional treatment of jaundice, which of the following is commonly used?
(A) The flowers of Butea monosperma.
(B) The seeds of Ricinus communis.
(C) The whole plant or leaves of Phyllanthus niruri or Emblica officinalis.
(D) The bark of Terminalia arjuna.

54. A paste made from the leaves of which plant is a common traditional remedy for various skin ailments like eczema and psoriasis?
(A) Ricinus communis
(B) Azadirachta indica
(C) Papaver somniferum
(D) Terminalia arjuna

55. Given below are two statements.
Statement I: The bark of Terminalia arjuna is a well-known traditional remedy for various heart diseases.
Statement II: The plant acts as a cardiotonic, strengthening the heart muscles.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

56. Which of the following plants is traditionally used as a blood purifier?
(A) Jatropha curcas
(B) Papaver somniferum
(C) Aconitum napellus
(D) Azadirachta indica

57. The use of certain plant extracts to expel parasitic worms from the body is a practice where the plant acts as a(n):
(A) Anthelmintic
(B) Antipyretic
(C) Analgesic
(D) Antiemetic

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58. For bronchial inflammation and asthma, a traditional remedy might involve the use of:
(A) The wood of Santalum album.
(B) The roots of Rauvolfia serpentina.
(C) The leaves of Ocimum sanctum (Tulsi).
(D) The seeds of Jatropha curcas.

59. In the context of traditional medicinal plants, which plant is most directly associated with treating amoebic dysentery?
(A) Holarrhena antidysenterica
(B) Emblica officinalis
(C) Terminalia arjuna
(D) Withania somnifera

60. Consider the following statements about traditional treatments:
1. Piles are often treated using plants that have laxative and anti-inflammatory properties.
2. Leucoderma treatment in traditional medicine may involve photosensitizing agents from plants.
3. There are no commonly documented traditional plant-based remedies for tuberculosis.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

61. Urogenital problems are traditionally treated with plants that have which of the following properties?
(A) Narcotic
(B) Cardiotonic

39. The oil from Ricinus communis seeds is commonly known as castor oil. What is its major traditional medicinal use?
(A) As a cardiac stimulant.
(B) As an antimalarial agent.
(C) As a potent laxative.
(D) As a treatment for tuberculosis.

40. Sandalwood, prized for its aromatic heartwood and oil, is obtained from which plant?
(A) Santalum album
(B) Pterocarpus marsupium
(C) Terminalia arjuna
(D) Jatropha curcas

41. Given below are two statements.
Statement I: The 'Triphala' formulation in Ayurveda consists of fruits from three different plants.
Statement II: Terminalia chebula, Terminalia bellerica, and Emblica officinalis are the three constituents of Triphala.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

42. Which of the following plants is specifically known in Ayurveda for its cardiotonic properties and is often called the 'guardian of the heart'?
(A) Withania somnifera
(B) Holarrhena antidysenterica
(C) Cassia fistula
(D) Terminalia arjuna

43. Withania somnifera, also known as 'Ashwagandha', is best described in ethnobotany as:
(A) A purgative
(B) An adaptogen and nervine tonic
(C) A psychoactive stimulant
(D) A source of red dye

44. The pungent and aromatic properties of ginger are due to the presence of compounds in its:
(A) Leaves
(B) Flowers
(C) Rhizome
(D) Seeds

45. Strychnine, a highly toxic alkaloid used in the past as a stimulant and currently as a pesticide, is extracted from the seeds of:
(A) Papaver somniferum
(B) Aconitum napellus
(C) Atropa belladonna
(D) Strychnos nux-vomica

46. Which plant is commonly known as 'Jamun', with its seeds being traditionally used for managing diabetes?
(A) Eugenia jambolana
(B) Butea monosperma
(C) Cassia fistula
(D) Terminalia chebula

47. The primary ethnobotanical use of Mentha arvensis is for extracting:
(A) A strong fibre for textiles.
(B) Menthol, used in balms and confectionary.
(C) A yellow dye for food.
(D) A potent insecticide.

48. The common onion, used worldwide as a food and in folk medicine, is botanically known as:
(A) Allium sativum
(B) Allium cepa
(C) Mentha arvensis
(D) Zingiber officinale

49. Which of the following plants is NOT part of the traditional Ayurvedic 'Triphala' formulation?
(A) Terminalia arjuna
(B) Terminalia chebula
(C) Emblica officinalis
(D) Terminalia bellerica

50. Match List I with List II and select the correct answer using the codes given below.
List I: (Plant Part Used)
P. Root
Q. Unripe fruit capsule
R. Flower bud
S. Heartwood
List II: (Plant Source)
1. Eugenia aromatica
2. Santalum album
3. Rauvolfia serpentina
4. Papaver somniferum
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1

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9. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Ethnobotany plays a crucial role in the discovery of new drugs.
Reason (R): Traditional knowledge of medicinal plants often provides leads for pharmacologically active compounds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

10. The study of plants used for personal adornment and care in traditional societies falls under which category?
(A) Ethnocosmetics
(B) Ethnonarcotics
(C) Ethnotoxicology
(D) Ethnomusicology

11. Which of the following statements about Ethnolinguistics is correct?
(A) The impact of plant genetics on modern linguistic systems.
(B) The analysis of plant-based poisons and medical antidotes.
(C) The specialized botanical branches focused on plant genetics.
(D) The links between language, culture, and the local plant world.

12. Consider the following statements:
1. Ethnobotany is a field that only documents the use of medicinal plants.
2. Archaeoethnobotany relies on the analysis of fossilized plant pollens and seeds.
3. Ethnomusicology can involve the study of plants used to make instruments.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 3 only
(D) 1, 2 and 3

13. The study of hallucinogenic or psychoactive plants used in traditional rituals is the primary focus of:
(A) Ethnopharmacology
(B) Ethno-gynaecology
(C) Ethnonarcotics
(D) Ethno-orthopaedics

14. What is the primary role of ethnobotany in the prevention of genetic diversity loss?
(A) Developing complex sets of genetically modified cash crops.
(B) Cultivating high-yield commercial crops for urban markets.
(C) Utilizing chemical fertilizers to enhance global plant growth.
(D) Conserving traditional crop varieties and wild plant relatives.

15. Given below are two statements.
Statement I: The Unani system of medicine originated in India during the Vedic period.
Statement II: The Homeopathic system of medicine is based on the principle "Similia Similibus Curentur" (let like be cured by like).
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

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16. A plant or animal species that is held sacred by a particular clan and is often protected from harm is known as a:
(A) Taboo
(B) Totem
(C) Simile
(D) Metaphor

17. Which of the following is a key role of ethnobotany in the development of modern society?
(A) Discouraging the use of traditional knowledge systems.
(B) Providing new models for sustainable agriculture and conservation.
(C) Exclusively promoting synthetic drug manufacturing.
(D) Replacing all traditional farming with industrial agriculture.

18. A 'taboo' in relation to plants within a community most accurately refers to:
(A) A cultural or religious prohibition against using or harming a specific plant.
(B) A plant that is worshipped as a deity.
(C) A plant used in the creation of musical

(C) Emetic
(D) Diuretic

62. While no single plant is a cure, which of the following is traditionally used as a supportive therapy for rheumatism due to its anti-inflammatory properties?
(A) Papaver somniferum
(B) Ricinus communis (castor oil application)
(C) Lawsonia inermis
(D) Cassia fistula

63. The use of Pterocarpus marsupium wood tumblers is a traditional method primarily aimed at managing:
(A) Jaundice
(B) Leukaemia
(C) Diabetes
(D) Heart disease

64. Which of the following diseases is typically NOT a primary focus of traditional treatment using common medicinal plants?
(A) Malaria
(B) Leukaemia
(C) Tuberculosis
(D) Cancer

65. The inherent ability of a single plant cell to divide and differentiate to form a whole new plant is termed:
(A) Totipotency
(B) Organogenesis
(C) Somatic hybridization
(D) Cryopreservation

66. What is the primary purpose of aseptic and sterilization techniques in plant tissue culture?
(A) To encourage faster growth of the explant.
(B) To prevent microbial contamination of the culture.
(C) To induce mutations in the plant cells.
(D) To reduce the nutrient requirements of the culture medium.

67. Which of the following is considered an 'explants' in the context of tissue culture?
(A) The entire parent plant.
(B) A small piece of tissue or organ used to initiate a culture.
(C) The nutrient medium used for growing cells.
(D) The final plantlet produced through micropropagation.

68. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Meristem culture is often used to produce virus-free plants.
Reason (R): The apical meristem of a plant is typically free from viruses even if the rest of the plant is infected.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

69. The culture of pollen grains to produce haploid plants is known as:
(A) Embryo culture
(B) Meristem culture
(C) Somatic hybridization
(D) Anther culture

70. The process of developing organs like shoots, roots, or flowers directly from a callus or explant in tissue culture is called:
(A) Organogenesis
(B) Totipotency
(C) Plasmolysis
(D) Cryopreservation

71. Match List I with List II and select the correct answer using the codes given below.
List I: (Tissue Culture Term)
P. Totipotency
Q. Explant
R. Anther Culture
S. Cryopreservation
List II: (Description)
1. Production of haploid plants
2. Storage in liquid nitrogen
3. Inherent potential to form a whole plant
4. Tissue used to initiate culture
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

72. What is somatic hybridization?

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(A) The production of a hybrid plant through normal sexual reproduction.
(B) The culture of somatic embryos to form plantlets.
(C) The fusion of protoplasts from two different plant species in vitro.
(D) The preservation of somatic cells at ultra-low temperatures.

73. Cryopreservation in plant tissue culture involves storing germplasm at:
(A) Room temperature (25°C)
(B) Ultra-low temperatures, typically in liquid nitrogen (-196°C)
(C) Refrigeration temperature (4°C)
(D) Very high temperatures (100°C)

74. Given below are two statements.
Statement I: Transgenic plants are organisms that have been genetically modified using recombinant DNA technology.
Statement II: Phytoremediation is a process where transgenic plants are used to synthesize pharmaceuticals.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

75. The use of plants to clean up contaminated soil, water, or air is known as:
(A) Cryopreservation
(B) Microbial fermentation
(C) Phytoremediation
(D) Somatic embryogenesis

76. Which of the following is a major application of plant tissue culture?
(A) Extraction of minerals from the soil.
(B) Production of fossil fuels.
(C) Monitoring air pollution levels.
(D) Large-scale production of uniform, disease-free plants.

77. An industrial fermenter is a vessel primarily designed to:
(A) Provide a controlled environment for the growth of microorganisms to produce a desired product.
(B) Carry out plant tissue culture on a large scale.
(C) Sterilize lab equipment using high-pressure steam.
(D) Extract oils from oilseeds using chemical solvents.

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78. Consider the following statements about Applied Botany techniques:
1. Embryo culture is used to rescue hybrid embryos that might abort in vivo.
2. Somatic hybridization requires the enzymatic removal of the cell wall to create protoplasts.
3. Transgenic plants can be engineered for traits like pest resistance or herbicide tolerance.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

79. In the context of oil-yielding crops, which of the following is significant?
(A) Cotton
(B) Wheat
(C) Soybean
(D) Gram

80. A plant that has a gene inserted from another species is best described as a:
(A) Somatic hybrid
(B) Haploid plant
(C) Mutant plant
(D) Transgenic plant

81. Which of the following is an example of a cereal crop?
(A) Wheat
(B) Lentil
(C) Soybean
(D) Cotton

82. Pulses are an important part of Economic Botany because they are a primary source of:
(A) Fibre
(B) Protein
(C) Oil
(D) Starch

83. Cotton is a major crop cultivated primarily for its:

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(A) Edible oil
(B) Protein-rich seeds
(C) Fibre
(D) Medicinal alkaloids

84. The historical review of ethnobotany helps in understanding:
(A) The future trends in genetic engineering.
(B) The chemical structure of plant-based drugs only.
(C) The process of industrial fermentation.
(D) The evolution of the study of human-plant interactions over time.

85. A researcher studying the use of plants in traditional veterinary medicine would be working in a field best described as:
(A) Ethnoveterinary medicine
(B) Ethnopaediatrics
(C) Ethnozoology
(D) Ethno-orthopaedics

86. Given below are two statements.
Statement I: A key goal of ethnobotanical research is to document indigenous knowledge before it is lost.
Statement II: This documentation has no practical application in modern science.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

87. Which of the following is NOT an example of a plant used in a major system of medicine (Ayurvedic, Unani, Homeopathic, Allopathic)?
(A) Rauvolfia serpentina
(B) Digitalis purpurea
(C) Atropa belladonna
(D) A genetically engineered plant that glows in the dark.

88. The phrase "as strong as an oak" is an example of a plant:
(A) Totem
(B) Simile
(C) Taboo
(D) Folktale

89. Which of the following is an incorrect pair of a plant and its ethnobotanical importance?
(A) Aloe vera - Timber production
(B) Cannabis sativa - Fibre and psychoactive compounds
(C) Jatropha curcas - Biodiesel
(D) Lawsonia inermis - Red dye (henna)

90. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): The study of plants in mythology is relevant to ethnobotany.
Reason (R): Myths often encode important information about a plant's uses, sacredness, or perceived properties within a culture.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

91. Which of the following represents a correct chronological order of the basic steps in creating a transgenic plant?
P. Identification and isolation of the desired gene.
Q. Transformation of plant cells with the gene.
R. Selection of transformed cells.
S. Regeneration of a whole plant from selected cells.
(A) P, Q, R, S
(B) Q, P, R, S
(C) P, S, Q, R
(D) S, R, Q, P

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92. The gel from the leaves of Aloe vera is traditionally used for:
(A) Its stimulating and narcotic effects.
(B) Treating burns and soothing skin irritations.
(C) As a potent poison for hunting.
(D) As a primary source of dietary protein.

93. 'Flame of the Forest' is the common name for which plant, known for its vibrant orange-red flowers used to make a traditional colour for the Holi festival?
(A) Cassia fistula
(B) Terminalia arjuna
(C) Azadirachta indica
(D) Butea monosperma

136. Which plant is the source of strychnine, a potent central nervous system stimulant and poison?
(A) Atropa belladonna
(B) Strychnos nux-vomica
(C) Aconitum napellus
(D) Papaver somniferum

137. Given below are two statements.
Statement I: The seeds of Eugenia jambolana are traditionally used to manage blood sugar levels.
Statement II: The fruits of Eugenia jambolana are poisonous and should not be consumed.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

138. Menthol, used in various balms for headache and cold, is chiefly derived from:
(A) Ocimum sanctum
(B) Zingiber officinale
(C) Eugenia aromatica
(D) Mentha arvensis

139. A patient suffering from rheumatism and joint pain is advised to apply a poultice and oil from a certain plant known for its anti-inflammatory properties. This plant is likely:
(A) Ricinus communis
(B) Papaver somniferum
(C) Cassia fistula
(D) Holarrhena antidysenterica

140. A traditional formulation for purifying the blood and treating skin infections would most likely include parts from:
(A) Terminalia arjuna
(B) Azadirachta indica
(C) Rauvolfia serpentina
(D) Pterocarpus marsupium

141. The condition of piles (hemorrhoids) is often traditionally treated with plants that possess which two key properties?
(A) Narcotic and sedative
(B) Astringent and anti-inflammatory
(C) Cardiotonic and diuretic
(D) Emetic and purgative

142. The creation of 'somatic embryos' from vegetative cells in a culture medium is a phenomenon central to:
(A) Somatic embryogenesis
(B) Anther culture
(C) Somatic hybridization
(D) Gametic embryogenesis

143. Which of the following is NOT an application of plant tissue culture?
(A) Production of secondary metabolites.
(B) Conservation of endangered species.
(C) Production of fossil fuels.
(D) Rapid clonal propagation.

144. Which of the following is an important drug-yielding plant that is widely cultivated and also found in the wild?
(A) Santalum album
(B) Jatropha curcas
(C) Triticum aestivum
(D) Withania somnifera

145. What is the fundamental difference between organogenesis and somatic embryogenesis in tissue culture?
(A) Organogenesis produces only roots, while somatic embryogenesis produces only shoots.
(B) Organogenesis can only be initiated from meristematic tissue, whereas somatic embryogenesis can be initiated from any cell.
(C) Organogenesis forms organs sequentially, while somatic embryogenesis forms a bipolar structure resembling a zygotic embryo.
(D) Organogenesis results in diploid plants, while somatic embryogenesis results in haploid plants.

146. Match List I with List II and select the correct answer from the codes given below.
List I: (Ethnobotany Sub-field)
P. Ethno-gynaecology
Q. Ethno-linguistics
R. Archaeoethnobotany
S. Ethnopharmacology
List II: (Focus of Study)
1. Study of plant names and vocabulary in a culture

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(B) Taboo
(C) Simile
(D) Folktale

105. The ethnobotanical study of musical instruments made from gourds, bamboo, or specific woods falls under:
(A) Ethnolinguistics
(B) Ethnotoxicology
(C) Ethnomusicology
(D) Ethnopaediatrics

106. Which of the following is a primary objective of ethnobotanical research?
(A) Replacing all traditional medicine with modern medicine.
(B) Patenting indigenous knowledge without benefit sharing.
(C) Focusing solely on the commercialization of local plants.
(D) Documenting and conserving diverse biocultural systems.

107. The potent toxicity of Aconitum napellus is due to the presence of alkaloids like aconitine, which affects the:
(A) Cardiovascular and central nervous systems
(B) Digestive system
(C) Respiratory system
(D) Skeletal system

108. Which part of Allium cepa (onion) is the primary edible portion?
(A) The root
(B) The modified leaves forming the bulb
(C) The flower
(D) The seeds

109. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Garlic (Allium sativum) has been used for centuries in folk medicine.
Reason (R): It contains sulfur compounds like allicin, which exhibit antibacterial and cardiovascular benefits.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

110. The name 'belladonna' for Atropa belladonna (meaning 'beautiful lady') originates from its historical use by women to:
(A) Make a red lipstick.
(B) Creating a specialized fragrant perfume.
(C) Dyeing hair through botanical extracts.
(D) Dilate their pupils for cosmetic effect.

111. Which plant is NOT primarily known for its medicinal or ethnobotanical uses, but rather as a major source of textile fibre?
(A) Azadirachta indica
(B) Gossypium hirsutum
(C) Cannabis sativa
(D) Withania somnifera

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112. Consider the following statements:
1. Ethno-gynaecology deals with plant use for veterinary purposes.
2. Ethno-ophthalmology concerns the traditional treatment of eye diseases.
3. Ethno-orthopaedics is the study of plants used for treating skeletal injuries.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 3 only
(D) 1, 2 and 3

113. The oil from which plant's seeds is non-edible and a promising source for biofuel?
(A) Ricinus communis
(B) Santalum album
(C) Piper nigrum
(D) Jatropha curcas

114. The 'King of Bitters' is a term sometimes applied to plants used in treating fever and liver disorders, while the 'Queen of Spices' is cardamom. The 'King of Spices' is:
(A) Black Pepper (Piper nigrum)
(B) Clove (Eugenia aromatica)
(C) Ginger (Zingiber officinale)
(D) Turmeric (Curcuma longa)

115. Given below are two statements.
Statement I: The heartwood of Pterocarpus marsupium is traditionally used to control blood sugar levels.
Statement II: The roots of the same plant are the primary source of the drug reserpine.

(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

116. The alkaloids morphine and codeine are powerful analgesics derived from:
(A) Rauvolfia serpentina
(B) Atropa belladonna
(C) Strychnos nux-vomica
(D) Papaver somniferum

117. Which of the following is an incorrect statement regarding Ricinus communis?
(A) The oil from its seeds is a strong purgative.
(B) The plant is a primary source for natural rubber.
(C) The seed itself is highly toxic if ingested due to the presence of ricin.
(D) The oil is used externally for rheumatic pains.

118. The bark of Terminalia arjuna is a well-regarded traditional medicine for:
(A) Heart ailments
(B) Leprosy
(C) Tuberculosis
(D) Malaria

119. A traditional healer advises a patient with a persistent dry cough and breathing difficulty to chew on the leaves of a specific plant known for its soothing effect on the bronchial tract. Which plant is most likely being recommended?
(A) Jatropha curcas
(B) Ocimum sanctum
(C) Cassia fistula
(D) Santalum album

120. In a case of leucoderma (vitiligo), traditional medicine might employ plants that contain psoralens, which are:
(A) Strong anti-inflammatory agents
(B) Potent diuretics
(C) Photosensitizing compounds
(D) Cardiac stimulants

121. The main advantage of using embryo culture in plant breeding is:
(A) To produce haploid plants.
(B) To create genetically identical copies of a plant.
(C) To produce virus-free plants.
(D) To rescue hybrid embryos from incompatible crosses.

122. Match List I with List II and select the correct answer using the codes given below.
List I: (Disease/Condition)
P. Amoebic Dysentery
Q. Heart Disease
R. High Blood Pressure
S. Skin Disease
List II: (Associated Plant)
1. Rauvolfia serpentina
2. Azadirachta indica
3. Terminalia arjuna
4. Holarrhena antidysenterica
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-4, S-1

123. The term 'Economic Botany' primarily deals with:
(A) The study of the internal financial management of botanical gardens.
(B) The study of the economic impact of plant diseases on agriculture.
(C) The study of plants that are of economic or commercial value to humans.
(D) The cost-benefit analysis of ethnobotanical research.

124. Which of the following is a key requirement for a substance to be used as an explant in tissue culture?
(A) It must be a root tip.
(B) Containing living cells capable of division.
(C) Sourced from the flowering parts of a plant.
(D) Being processed until completely dehydrated.

125. The process of using microorganisms to produce industrial products like enzymes, antibiotics, or beverages in a controlled bioreactor is called:
(A) Phytoremediation
(B) Somatic hybridization
(C) Cryopreservation
(D) Microbial fermentation

126. A Bt-crop is a transgenic plant that:

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(A) Produces its own insecticide.
(B) Is resistant to a specific herbicide.
(C) Has a higher vitamin content.
(D) Can grow in high-salt soils.

127. Which of the following is an example of a major pulse crop?
(A) Wheat
(B) Soybean
(C) Gram (Chickpea)
(D) Sugarcane

128. Arrange the following developments in the history of ethnobotany in a likely chronological sequence:
P. Use of sophisticated phytochemical analysis to validate traditional claims.
Q. Early documentation of plant uses by explorers and naturalists.
R. Formal coining of the term 'Ethnobotany' by John Harshberger.
S. Analysis of plant remains from ancient human settlements (Archaeoethnobotany).
(A) Q, R, S, P
(B) R, Q, P, S
(C) Q, S, R, P
(D) S, Q, P, R

129. The study of poisonous plants used by indigenous people falls under the purview of:
(A) Ethnotoxicology
(B) Ethnopharmacology
(C) Ethnoecology
(D) Ethnopaediatrics

130. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Plant tissue culture requires a sterile environment.
Reason (R): The nutrient-rich culture medium is highly susceptible to growth of bacteria and fungi, which can outcompete and kill the plant tissue.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

131. The primary ethnobotanical significance of Santalum album lies in its:
(A) Highly nutritious fruit.
(B) Strong, durable timber for construction.
(C) Potent insecticidal leaves.
(D) Aromatic heartwood and essential oil.

132. Which of the following is a correct statement about the Unani system of medicine?
(A) It is based on the principle of treating with substances that produce similar symptoms.
(B) It is based on the teachings of Greek physicians Hippocrates and Galen.
(C) It is an indigenous Indian system documented in the Vedas.
(D) It relies exclusively on spiritual healing and incantations.

133. Consider the following statements about ethnobotanical concepts:
1. Domestication of plants by tribal people is a process that has contributed to global agricultural biodiversity.
2. A totem is a plant that is forbidden to be consumed by a community.
3. Wildlife protection in tribal communities is often linked to the concept of sacred groves.
Which of the above statement(s) is/are correct?
(A) 1 and 3 only
(B) 2 only
(C) 1 and 2 only
(D) 1, 2 and 3

134. Withania somnifera is called 'Ashwagandha' (smell of a horse) partly because:
(A) Wild horses are specifically fond of this plant.
(B) Flowers of the plant resemble a horse's head.
(C) Plant species commonly grow in horse stables.
(D) Roots believed to impart strength and vitality.

135. The pungent principle in ginger (Zingiber officinale) responsible for its medicinal properties is:
(A) Gingerol
(B) Atropine
(C) Allicin
(D) Reserpine

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157. Which plant's common name is 'Sarpagandha', alluding to its traditional use as an antidote for snake bites and for treating insanity?
(A) Rauvolfia serpentina
(B) Withania somnifera
(C) Strychnos nux-vomica
(D) Holarrhena antidysenterica

158. Consider the following statements regarding plant tissue culture:
1. Anther culture is used to produce diploid plants.
2. The medium for tissue culture must be sterile and contain necessary nutrients and hormones.
3. Somatic hybridization involves the fusion of gametes from two different species.

Which of the above statement(s) is/are correct?
(A) 2 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

159. The red dye obtained from Lawsonia inermis is primarily extracted from its:
(A) Roots
(B) Flowers
(C) Seeds
(D) Leaves

160. A protein-rich pulse product from a non-timber forest plant belongs to which of the following categories?
(A) Pulse
(B) Cereal
(C) Oilseed
(D) Fibre

161. The term 'Ethno-ophthalmology' refers to the study of traditional remedies for ailments related to the:
(A) Skin
(B) Bones
(C) Eyes
(D) Nerves

162. The concept of 'totemism' often results in:
(A) Over-exploitation of the totem species.
(B) The protection and conservation of the totem species.
(C) The use of the totem species as a primary food source.
(D) The complete disregard for the totem species.

163. Which of the following pairs is incorrectly matched?
(A) Ethnomedicine - Study of traditional medicine
(B) Ethnotaxonomy - Study of folk classification of plants
(C) Ethnoecology - Study of plant-based poisons
(D) Ethnomusicology - Study of plants in music

164. The fruit pulp of Cassia fistula is known for what medicinal property?
(A) Cardiotonic
(B) Antipyretic
(C) Analgesic
(D) Purgative

165. The spice 'clove' is which part of the Eugenia aromatica plant?
(A) The dried, unopened flower bud
(B) The dried seed
(C) The dried leaf
(D) The dried root

166. Which of the following chronological sequences of events is correct?
P. Establishment of agriculture.
Q. Emergence of hunter-gatherer societies.
R. Formalization of Ethnobotany as an academic discipline.
S. Use of plants for basic needs like food and shelter.
(A) S, Q, P, R
(B) Q, S, P, R
(C) Q, P, S, R
(D) S, P, Q, R

167. Given below are two statements.
Statement I: Jatropha curcas seeds are a rich source of edible protein for human consumption.
Statement II: The seeds contain toxic compounds, making them unsuitable for consumption without processing, but the oil is useful for biofuel.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

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2. Study of plant remains at ancient sites
3. Study of pharmacological action of traditional remedies
4. Study of plants used for women's health issues

(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

147. A tribal community's belief that a specific grove of trees is home to a deity, thereby protecting it from being cut down, is an example of conservation through:
(A) Legal enforcement
(B) Cultural/religious belief
(C) Economic incentive
(D) Scientific management

148. The Homeopathic system of medicine was developed by:
(A) Hippocrates
(B) Charaka
(C) Ibn Sina
(D) Samuel Hahnemann

149. The process of plant domestication by tribal people typically involves:
(A) Selecting and propagating wild plants with desirable traits over generations.
(B) Genetic engineering in a laboratory.
(C) Applying large amounts of chemical fertilizers to wild plants.
(D) Crossing wild plants with commercially available hybrids.

150. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): The study of folklore and folktales is irrelevant to the scientific discipline of ethnobotany.
Reason (R): Folktales are fictional stories and do not contain verifiable information about plant properties.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) Both A and R are false.

151. Which plant is known as 'Indian Ginseng' and is used as an adaptogen in Ayurveda?
(A) Rauvolfia serpentina
(B) Zingiber officinale
(C) Withania somnifera
(D) Emblica officinalis

152. Which of the following is a key feature of a bioreactor or fermenter used in industrial microbiology?
(A) It allows for the control of parameters like temperature, pH, and oxygen.
(B) It operates only under aerobic conditions.
(C) It is an open system exposed to the atmosphere.
(D) It is exclusively used for growing plant cells.

153. A plant that can absorb heavy metals like lead and arsenic from the soil and accumulate them in its harvestable parts is useful for:
(A) Phytoextraction
(B) Phytostabilization
(C) Anther culture
(D) Phytoextraction

154. Which two plants are sources of important alkaloids used in allopathic medicine for treating hypertension and for pupil dilation, respectively?
(A) Aloe vera and Azadirachta indica
(B) Rauvolfia serpentina and Atropa belladonna
(C) Jatropha curcas and Lawsonia inermis
(D) Papaver somniferum and Ricinus communis

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155. Given below are two statements.
Statement I: Cryopreservation is a technique for the long-term preservation of plant germplasm.
Statement II: It involves the storage of biological materials at the temperature of liquid nitrogen.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

156. The development of a shoot or a root from a callus is an example of:
(A) Totipotency
(B) Cryopreservation
(C) Plasmolysis
(D) Differentiation

94. The purgative properties of Cassia fistula (Amaltas) are associated with which part of the plant?
(A) The pulp inside the fruit pods
(B) The flowers
(C) The leaves
(D) The root bark

95. Emblica officinalis (Amla) is a cornerstone of which traditional medicine system due to its rejuvenating and immunomodulatory properties?
(A) Allopathy
(B) Homeopathy
(C) Ayurveda
(D) Naturopathy

96. Consider the following statements about Terminalia chebula:
1. It is one of the three fruits in the 'Triphala' formulation.
2. It is traditionally known for its laxative and astringent properties.
3. It is the primary source of commercial sandalwood oil.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

97. The process of microbial fermentation is important in the industrial production of all of the following EXCEPT:
(A) Antibiotics
(B) Bioethanol
(C) Yoghurt
(D) Wooden furniture

98. A scientist wants to create a hybrid between two sexually incompatible species of potato. Which technique would be most appropriate?
(A) Anther culture
(B) Somatic hybridization
(C) Meristem culture
(D) Embryo culture

99. In plant tissue culture, an autoclave is used for:
(A) Incubation at low temperatures
(B) Rapid freezing of explants
(C) Sterilization
(D) Providing light for photosynthesis

100. Match List I with List II and select the correct answer using the codes given below.
List I: (Common Name)
P. Tulsi
Q. Ashwagandha
R. Sarpagandha
S. Kalmegh
List II: (Botanical Name)
1. Withania somnifera
2. Rauvolfia serpentina
3. Andrographis paniculata
4. Ocimum sanctum
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-1, S-2

101. A plant used in phytoremediation that absorbs and breaks down contaminants within its tissues is performing:
(A) Phytoextraction
(B) Phytostabilization
(C) Rhizofiltration
(D) Phytodegradation

102. The study of how different cultures perceive, name, and classify plants in their environment is the core of:
(A) Ethnotaxonomy
(B) Ethnoecology
(C) Ethnopharmacology
(D) Ethnomusicology

103. Given below are two statements.
Statement I: The Allopathic system of medicine completely rejects the use of plant-derived compounds.
Statement II: Many important allopathic drugs like morphine and atropine were originally isolated from plants.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

104. A social rule that forbids the cutting of a particular tree in a village is an example of a plant-related:
(A) Totem

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168. The compound reserpine, extracted from Rauvolfia serpentina, was a landmark drug for the treatment of:
(A) Diabetes
(B) Malaria
(C) Hypertension
(D) Tuberculosis

169. Match List I with List II and select the correct answer using the codes given below.
List I: (Plant)
P. Ocimum sanctum
Q. Ricinus communis
R. Piper nigrum
S. Holarrhena antidysenterica
List II: (Primary Use/Property)
1. Purgative oil
2. Spice, bio-enhancer
3. Anti-dysentery
4. Adaptogen, used for cough/cold
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-3, S-1

170. What is the key principle of the Homeopathic system of medicine?
(A) The theory of 'tridosha'.
(B) The principle of 'like cures like' using highly diluted substances.
(C) The use of opposites to cure diseases.
(D) A focus on surgical intervention and synthetic drugs.

171. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): The technique of somatic hybridization allows for the creation of plant hybrids that cannot be produced by conventional sexual crossing.
Reason (R): It bypasses the sexual reproduction process by fusing somatic cell protoplasts.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

172. To produce a haploid plant for breeding purposes, which tissue culture technique would be most suitable?
(A) Meristem culture
(B) Somatic hybridization
(C) Anther/Pollen culture
(D) Embryo rescue

173. A transgenic plant engineered to tolerate glyphosate, a common herbicide, allows a farmer to:
(A) Utilize significantly less water for irrigation.
(B) Harvest the crop earlier than the usual cycle.
(C) Sell crops at higher prices due to better taste.
(D) Spray herbicides without harming the target crop.

174. Which of the following is considered a pulse?
(A) Cicer arietinum
(B) Triticum aestivum
(C) Oryza sativa
(D) Glycine max

175. The specific field of study focused on the traditional knowledge of plants used for children's ailments is:
(A) Ethno-gynaecology
(B) Ethnopaediatrics
(C) Ethno-orthopaedics
(D) Ethnoecology

176. Which of the following best describes a 'sacred grove'?
(A) A commercial plantation of medicinal herbs.
(B) A patch of forest protected on the basis of religious beliefs.
(C) A research plot for studying plant genetics.
(D) A garden where poisonous plants are cultivated.

177. The use of the phrase "a face as pale as a lily" exemplifies the use of a plant in a:
(A) Simile
(B) Metaphor
(C) Totem
(D) Taboo

178. Consider the following statements about Ethnobotanical plants:

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1. Aconitum napellus is a benign herb used in salads.
2. Atropa belladonna is the source of the stimulant caffeine.
3. Cannabis sativa can be a source of both fibre and psychoactive drugs.

Which of the above statement(s) is/are correct?
(A) 3 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

179. The bark of Holarrhena antidysenterica contains alkaloids that are effective against:
(A) The malarial parasite Plasmodium.
(B) The bacterium Mycobacterium tuberculosis.
(C) The amoeba Entamoeba histolytica.
(D) The fungus Candida albicans.

180. The adaptogenic properties of Withania somnifera (Ashwagandha) mean that it helps the body to:
(A) Cope with physical and mental stress.
(B) Rapidly lose weight.
(C) Digest fatty foods more efficiently.
(D) Stay awake for prolonged periods.

181. Given below are two statements.
Statement I: The rhizome of Zingiber officinale is used in traditional medicine to treat nausea and motion sickness.
Statement II: The same rhizome is also a major source for the production of industrial ethanol.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

182. A traditional remedy for expelling intestinal worms (anthelmintic) might involve using preparations from all of the following EXCEPT:
(A) Butea monosperma seeds
(B) Azadirachta indica parts
(C) Ricinus communis oil
(D) Terminalia arjuna bark

183. The primary purpose of using laminar air flow cabinets in plant tissue culture is to:
(A) Maintain a constant high temperature.
(B) Provide a sterile working area.
(C) Supply carbon dioxide to the cultures.
(D) Automate the transfer of explants.

184. The fusion of a protoplast from species A with a protoplast from species B results in a:
(A) Transgenic organism
(B) Zygotic embryo
(C) Somatic hybrid or cybrid
(D) Haploid cell line

185. A major cereal crop, which is a staple food and source of carbohydrates, is:
(A) Cotton
(B) Soybean
(C) Linseed
(D) Wheat

186. The concept of using plants to stabilize, remove, or degrade environmental contaminants is broadly termed:
(A) Phytoremediation
(B) Plantibody production
(C) Fermentation
(D) Micropropagation

187. Which of the following is NOT a direct application of plant tissue culture?
(A) Germplasm conservation through cryopreservation.
(B) Production of synthetic fertilizers.
(C) Micropropagation of elite plant varieties.
(D) Production of secondary metabolites in cell cultures.

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188. In the context of economic botany, what category does cotton belong to?
(A) Cereal
(B) Fibre-yielding plant
(C) Pulse
(D) Oil-yielding plant

189. The study of plant-related words, their origins, and their use within a culture's language is known as:
(A) Ethnolinguistics
(B) Ethnotaxonomy
(C) Ethnogeography
(D) Ethnopedology

190. What system of medicine, with origins in ancient Greece and developed by Arabs and

Persians, is based on the concept of balancing the four humors in the body?
(A) Ayurveda
(B) Homeopathy
(C) Unani
(D) Siddha

191. Match List I with List II and select the correct answer from the codes given below.
List I: (Term)
P. Totem
Q. Taboo
R. Simile
S. Folklore
List II: (Description)
1. A story or belief passed down through generations
2. A sacred emblem of a family or clan, often a plant or animal
3. A prohibition imposed by social custom
4. A figure of speech involving comparison using 'like' or 'as'
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-3, S-1
(D) P-3, Q-1, R-4, S-2

192. Which part of Papaver somniferum is the source of opium alkaloids?
(A) The latex from the incised unripe capsule
(B) The mature seeds
(C) The latex from the unscratched ripe capsule
(D) The root

193. The term "Triphala" in Ayurveda refers to a combination of three:
(A) Barks
(B) Roots
(C) Fruits
(D) Leaves

194. A researcher wants to obtain a large number of genetically identical banana plants quickly from a high-yielding mother plant. The most suitable technique would be:
(A) Somatic hybridization
(B) Anther culture
(C) Micropropagation
(D) Genetic modification

195. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Soybean is an economically important crop.
Reason (R): It is cultivated primarily for its high starch content, similar to wheat.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

196. The process by which protoplasts are obtained from plant cells for somatic hybridization involves the use of:
(A) Strong acids and bases
(B) Enzymes like cellulase and pectinase
(C) High-pressure homogenization
(D) Liquid nitrogen

197. Which of the following is an example of a drug-yielding plant found widely in both cultivation and the wild?
(A) Allium cepa
(B) Cassia fistula
(C) Withania somnifera
(D) Piper nigrum

198. Ethno-gynaecology is the branch of ethnobotany that focuses on:
(A) Plants used for treating eye ailments.
(B) Plants used for traditional veterinary medicine.
(C) Plants used for treating children's diseases.
(D) Plants related to female reproductive health, childbirth, and contraception.

199. The flowers of Butea monosperma are traditionally used to:
(A) Make a yellow or orange dye.
(B) Treat heart conditions.
(C) Produce a strong fibre.
(D) Expel intestinal worms.

200. Given below are two statements.
Statement I: Anther culture gives rise to diploid plants.
Statement II: Meristem culture is ideal for producing virus-free plants.
(A) Both Statement I and Statement II are true.

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(B) Rauvolfia serpentina
(C) Santalum album
(D) Holarrhena antidysenterica

247. A sterile environment is a critical prerequisite for successful plant tissue culture because:
(A) The hormones used in the media are deactivated by microorganisms.
(B) Microorganisms increase the pH of the media to lethal levels.
(C) Microorganisms compete for nutrients and can produce toxins harmful to the plant tissue.
(D) The glass containers can be damaged by microbial growth.

248. The primary advantage of producing plants via anther culture is the production of:
(A) Virus-free plants
(B) Haploid plants
(C) Somatic hybrids
(D) Transgenic plants

249. Which of the following is a process of phytoremediation?
(A) Using plant tissue culture to create new varieties.
(B) Using plants to absorb and accumulate heavy metals from soil.
(C) Using microbial fermentation to produce antibiotics.
(D) Using plants as a source for biofuel.

250. Match List I with List II and select the correct answer using the codes given below.
List I: (Technique)
P. Meristem Culture
Q. Anther Culture
R. Somatic Hybridization
S. Cryopreservation
List II: (Primary Goal)
1. Overcoming sexual incompatibility
2. Production of haploids
3. Long-term germplasm storage
4. Production of virus-free plants
(A) P-4, Q-2, R-1, S-3
(B) P-1, Q-2, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-3, S-1

251. Which plant is the source of henna, a dye used for body art and hair colouring?
(A) Azadirachta indica
(B) Lawsonia inermis
(C) Butea monosperma
(D) Emblica officinalis

252. The term "ethno" in ethnobotany refers to:
(A) A specific group of people or culture.
(B) The ethics of plant research.
(C) The botanical characteristics of plants.
(D) The economic valuation of plants.

253. Which of the following pairs of plant and its main use is incorrect?
(A) Jatropha curcas - Biofuel
(B) Pterocarpus marsupium - Wood for diabetes management
(C) Santalum album - Edible fruit
(D) Piper nigrum - Spice

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254. Given below are two statements.
Statement I: Industrial fermentation is a process that can occur only in the presence of oxygen.
Statement II: Fermenters are designed to control variables like temperature, pH, and aeration to optimize microbial production.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

255. The concept of totipotency is fundamental to plant tissue culture. It was first proposed by:
(A) R. H. Whittaker
(B) C. Linnaeus
(C) G. Haberlandt
(D) G. Mendel

256. What is the most appropriate explant to use to obtain virus-free plants from an infected parent plant?
(A) A mature leaf
(B) A piece of the root
(C) A flower petal
(D) The apical meristem

257. The creation of a "pomato," a somatic hybrid of potato and tomato, is an application of which technique?
(A) Somatic hybridization

explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

212. To treat a severe skin infection like scabies, a traditional healer would most likely prescribe a paste or oil made from:
(A) Azadirachta indica
(B) Terminalia arjuna
(C) Pterocarpus marsupium
(D) Eugenia jambolana

213. In tissue culture, the term for a mass of undifferentiated and dividing plant cells is:
(A) Explant
(B) Callus
(C) Embryoid
(D) Protoplast

214. The primary goal of cryopreservation is:
(A) Short-term storage of plant tissues at 4°C.
(B) Long-term conservation of genetic resources in a viable state.
(C) To induce mutations through cold shock.
(D) To sterilize plant tissues before culture.

215. A plant that is genetically engineered to produce a human protein (like insulin) is an example of a:
(A) Transgenic plant used for molecular farming
(B) Somatic hybrid
(C) Haploid plant
(D) Phytoremediator

216. Ethnobotany is an interdisciplinary science that combines botany with which other field?
(A) Geology
(B) Particle Physics
(C) Anthropology
(D) Computer Science

217. A researcher investigating the local names of plants and their meanings in a tribal dialect is working within the scope of:
(A) Ethnotoxicology
(B) Ethnoecology
(C) Ethno-orthopaedics
(D) Ethnolinguistics

218. Given below are two statements.
Statement I: The Ayurvedic system of medicine has its roots in ancient Indian scriptures like the Vedas.
Statement II: The Unani system of medicine was developed independently in China.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

219. The process of artificial selection of wild plants by humans to create crops better suited for agriculture is called:
(A) Natural selection
(B) Genetic drift
(C) Domestication
(D) Pollination

220. Which of the following is the best example of a plant simile?
(A) "The banyan tree is the home of spirits."
(B) "Her skin was as smooth as a lotus petal."
(C) "Do not eat the fruit of the forbidden tree."
(D) "The great chief is our tribe's oak tree."

221. Match List I with List II and select the correct answer from the codes given below.
List I: (Botanical Name)
P. Emblica officinalis
Q. Aloe vera
R. Lawsonia inermis
S. Cannabis sativa
List II: (Common Name / Product)
1. Henna
2. Hemp/Marijuana
3. Amla
4. Aloe gel
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-1, S-2

222. The most potent psychoactive compound found in Cannabis sativa is:
(A) Natural Cannabidiol (CBD).
(B) Hempin
(C) Sativin
(D) Tetrahydrocannabinol (THC)

223. The 'gum-kino' obtained from Pterocarpus marsupium has which prominent medicinal property?

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(A) Astringent
(B) Purgative
(C) Narcotic
(D) Diuretic

224. For a person suffering from leucoderma, traditional medicine might use a plant with photosensitizing properties that works by:
(A) Lightening skin to match patches.
(B) Providing a sun protection layer.
(C) Stimulating pigment upon UV exposure.
(D) Reducing general skin inflammation.

225. Which of the following plants has traditional uses as an anti-pyretic (fever-reducer)?
(A) Azadirachta indica
(B) Santalum album
(C) Eugenia jambolana
(D) Lawsonia inermis

226. What is the role of an impeller in an industrial fermenter?
(A) To mix the contents and ensure uniform distribution of cells, nutrients, and oxygen.
(B) To measure the temperature of the medium.
(C) To introduce sterile air into the medium.
(D) To remove the final product from the fermenter.

227. Anther culture is a technique that exploits the totipotency of:
(A) Somatic cells
(B) Microspores (pollen)
(C) Zygotic embryos
(D) Meristematic cells

228. The development of an entire plant from a single, non-reproductive cell demonstrates the principle of:
(A) Organogenesis
(B) Somatic Hybridization
(C) Totipotency
(D) Phytoremediation

229. Which of the following is a fibre-yielding plant of economic importance?
(A) Cicer arietinum
(B) Solanum tuberosum
(C) Mangifera indica
(D) Gossypium species

230. A plant's ability to take up contaminants through its roots and store them in the shoots and leaves is a mechanism called:
(A) Phytoextraction
(B) Phytodegradation
(C) Phytostabilization
(D) Rhizofiltration

231. Which ethnobotanical sub-discipline is concerned with the use of plants in rituals involving altered states of consciousness?
(A) Ethnocosmetics
(B) Ethnonarcotics
(C) Ethnopaediatrics
(D) Ethno-orthopaedics

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232. Given below are two statements.
Statement I: The historical review of ethnobotany shows a shift from simple documentation to scientific validation.
Statement II: Modern ethnobotany often involves phytochemical and pharmacological analysis of traditional remedies.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

233. The role of folklore in ethnobotany is significant because it can:
(A) Provide a legal framework for plant conservation.
(B) Give precise instructions for industrial-scale extraction of companies.
(C) Offer clues about the cultural and medicinal importance of plants.
(D) Replace the need for scientific experimentation.

234. Which of the following plants is a source of a potent neurotoxin that is also a central nervous system stimulant?
(A) Aloe vera
(B) Emblica officinalis
(C) Zingiber officinale
(D) Strychnos nux-vomica

235. The seeds of Eugenia jambolana are traditionally used in the management of which metabolic disorder?
(A) Diabetes mellitus

(B) Gout
(C) Phenylketonuria
(D) Scurvy

236. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Meristem culture is a reliable method for obtaining virus-free plants.
Reason (R): The vascular tissues, which transport viruses, are not yet developed in the apical meristem.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

237. Consider the following statements about plant tissue culture applications:
1. Cryopreservation is a method for short-term storage of explants at 4°C.
2. Somatic hybridization is a way to create hybrids between sexually incompatible species.
3. Anther culture is used to produce homozygous diploid lines rapidly.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 2 only
(D) 1, 2 and 3

238. In the context of economic botany, soybean (Glycine max) is classified as a(n):
(A) Cereal crop
(B) Oilseed crop
(C) Fibre crop
(D) Spice crop

239. 'Golden Rice' is a well-known example of a transgenic plant. It was developed to:
(A) Resist a variety of common agricultural pests.
(B) Tolerate exceptionally high levels of soil salt.
(C) Produces beta-carotene, a Vitamin A precursor.
(D) Grow at a faster rate to produce higher yields.

240. The definition of ethnobotany encompasses the study of all interactions between people and plants, including:
(A) Use as food, medicine, and shelter only.
(B) Use in language, ritual, and art.
(C) Use for commercial purposes only.
(D) Use by non-human primates.

241. The sub-discipline of ethnobotany that would study the traditional use of plant-based fish poisons is:
(A) Ethnotoxicology
(B) Ethnomedicine
(C) Ethnoecology
(D) Ethnolinguistics

242. A plant species that is believed to be the ancestor of a clan and is therefore protected by them is an example of a:
(A) Taboo
(B) Totem
(C) Simile
(D) Metaphor

243. The bark of which plant is renowned in traditional Indian medicine for its beneficial effects on the heart?
(A) Cassia fistula
(B) Terminalia arjuna
(C) Butea monosperma
(D) Holarrhena antidysenterica

244. The latex of Papaver somniferum is the source of a class of alkaloids known as:
(A) Opiates
(B) Cannabinoids
(C) Cocaines
(D) Strychnines

245. Which of the following is NOT one of the three plants constituting the Ayurvedic formula 'Triphala'?
(A) Emblica officinalis
(B) Terminalia chebula
(C) Withania somnifera
(D) Terminalia bellerica

246. To treat a patient with amoebic dysentery, a traditional practitioner would most likely use a preparation from:
(A) Terminalia arjuna

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(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

201. The 'Flame of the Forest' (Butea monosperma) is NOT typically used for which of the following purposes?
(A) As a source of dye.
(B) As a fodder for cattle.
(C) As a host for the lac insect.
(D) As a primary source of edible fruit for humans.

202. Which of the following is a key step in a microbial fermentation process?
(A) Introduction of a sterile explant.
(B) Sterilization of the nutrient medium and fermenter.
(C) Fusion of protoplasts from two different microbes.
(D) Regeneration of the microbe into a multicellular organism.

203. A major Kharif crop cultivated primarily for its seeds which are rich in oil and protein is:
(A) Wheat
(B) Gram
(C) Soybean
(D) Mustard

204. Arrange the steps for somatic hybridization in the correct order:
P. Fusion of protoplasts.
Q. Isolation of protoplasts from parent cells.
R. Regeneration of hybrid plant from the fused cell.
S. Selection of hybrid cells.
(A) Q, P, S, R
(B) P, Q, S, R
(C) Q, S, P, R
(D) P, R, Q, S

205. The study of plant remains found in association with ancient human settlements is:
(A) Palaeobotany
(B) Ethnomedicine
(C) Ethnotaxonomy
(D) Archaeoethnobotany

206. Which of the following is an example of a plant taboo?
(A) A specific clan being forbidden from eating the fruit of a particular tree.
(B) A community worshipping a Banyan tree.
(C) Using bamboo to build houses.
(D) A story about how the first coconut tree grew.

207. The Allopathic system of medicine is also known as:
(A) Traditional medicine
(B) Modern or Western medicine
(C) Ayurvedic medicine
(D) Unani medicine

208. The ethnobotanical importance of Eugenia aromatica is its use as:
(A) A botanical purgative.
(B) Spice and antiseptic oil.
(C) Source of textile fibre.
(D) Ritual-based hallucinogen.

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209. Consider the following statements:
1. Terminalia arjuna is primarily used for respiratory ailments.
2. Terminalia bellerica is one of the components of Triphala.
3. Terminalia chebula is known as the 'King of Medicines' in some traditional systems.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

210. The oil from Ricinus communis is used as a laxative, but the seed itself is deadly poisonous because it contains:
(A) Strychnine
(B) Atropine
(C) Morphine
(D) Ricin

211. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Ocimum sanctum holds a revered place in many cultures and traditional medicine.
Reason (R): It is primarily cultivated for its high-value timber.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct

(B) Anther culture
(C) Meristem culture
(D) Transgenesis

258. Which of the following is a major cereal crop typically grown in the Rabi season?
(A) Soybean
(B) Wheat
(C) Rice
(D) Maize

259. The study of traditional plant-based remedies for women's health issues falls under:
(A) Ethnopaediatrics
(B) Ethno-orthopaedics
(C) Ethno-gynaecology
(D) Ethno-dermatology

260. Consider the following statements about Rauvolfia serpentina:
1. Its common name is Sarpagandha.
2. The roots are the primary source of the alkaloid reserpine.
3. It is traditionally used to lower blood pressure.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

261. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Ethnobotanical knowledge is static and does not change over time.
Reason (R): Cultural practices and the environment are constantly evolving, leading to changes in how people use plants.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

262. The pungent spice known as black pepper is the dried fruit of which plant?
(A) Zingiber officinale
(B) Piper nigrum
(C) Eugenia aromatica
(D) Allium sativum

263. Aseptic techniques in tissue culture lab involve all of the following EXCEPT:
(A) Sterilizing media in an autoclave.
(B) Working in a laminar air flow hood.
(C) Surface sterilizing explants with alcohol or bleach.
(D) Adding soil to the culture medium to provide nutrients.

264. The primary product of economic importance from Santalum album is:
(A) Its aromatic heartwood and oil.
(B) Its sweet, edible fruit.
(C) Its strong, flexible fibre.
(D) Its protein-rich leaves.

265. What is the main purpose of anther culture?
(A) To create somatic hybrids.
(B) To conserve endangered plant species.
(C) To obtain haploid plants for breeding.
(D) To produce virus-free clones.

266. Which of the following statements correctly identifies the role of a plant in phytoremediation?
(A) A plant that releases toxins into the soil to kill harmful bacteria.
(B) A plant that absorbs and metabolizes organic pollutants from contaminated soil.
(C) A plant that is genetically modified to resist pests and diseases.
(D) A plant that is used to produce pharmaceutical drugs.

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267. Arrange the following in a logical sequence of application in a plant breeding program:
P. Anther culture to produce haploid plants.
Q. Creation of a hybrid by crossing two parent lines.
R. Chromosome doubling of haploids to create homozygous diploid lines.
S. Selection of superior homozygous lines for variety release.
(A) Q, P, R, S
(B) P, Q, R, S
(C) Q, R, S, P
(D) P, S, R, Q

268. In the context of economic botany, pulses are valued for their high content of:
(A) Oil
(B) Starch
(C) Vitamins

(D) Protein

269. The historical use of Atropa belladonna to dilate pupils is due to its content of the alkaloid:
(A) Morphine
(B) Atropine
(C) Quinine
(D) Reserpine

270. Given below are two statements.
Statement I: Totipotency refers to the ability of a plant cell to regenerate into a complete plant.
Statement II: This ability is lost as soon as a cell differentiates.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

271. Match List I with List II and select the correct answer from the codes given below.
List I: (Common Name)
P. Neem
Q. Tulsi
R. Henna
S. Garlic
List II: (Botanical Name)
1. Lawsonia inermis
2. Allium sativum
3. Azadirachta indica
4. Ocimum sanctum
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

272. The study of the traditional management of ecosystems by indigenous peoples is known as:
(A) Ethnotaxonomy
(B) Ethnoecology
(C) Ethnopharmacology
(D) Ethnomusicology

273. The primary reason for wildlife protection in many tribal communities is often rooted in:
(A) Government laws and regulations.
(B) Economic benefits from tourism.
(C) Cultural and spiritual beliefs, such as totemism.
(D) Scientific understanding of ecosystem balance.

274. The plant Strychnos nux-vomica is ethnobotanically significant as the source of:
(A) The painkiller morphine.
(B) The antimalarial quinine.
(C) The tranquilizer reserpine.
(D) The poison and stimulant strychnine.

275. A patient suffering from jaundice is traditionally advised to consume plants that support liver function. Which of the following is well-known for this property?
(A) Emblica officinalis (Amla)
(B) Aconitum napellus
(C) Papaver somniferum
(D) Atropa belladonna

276. In plant tissue culture, what is an 'explant'?
(A) A plant that has been grown outside its natural habitat.
(B) A small, sterile piece of plant tissue used to initiate a culture.
(C) The nutrient medium on which the tissue is grown.
(D) A plant that has been rejected from the culture process.

277. The main goal of somatic hybridization is to:
(A) Produce haploid plants.
(B) Create hybrids between species that cannot be crossed sexually.
(C) Clone a single parent plant into many identical copies.
(D) Introduce a single foreign gene into a plant.

278. Which of the following is a characteristic of a transgenic plant?
(A) It contains a gene or genes inserted through genetic engineering.
(B) It is produced by fusing two different protoplasts.
(C) It is grown from a culture of a single pollen grain.
(D) It is always sterile and cannot reproduce.

279. The study of plant use for treating animals in traditional societies is called:
(A) Ethnopaediatrics
(B) Ethnoveterinary medicine
(C) Ethnozoology
(D) Ethno-orthopaedics

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280. Consider the following ethnobotanical pairings:
1. Ethnotoxicology: Study of plant poisons.
2. Ethnocosmetics: Study of plants for personal care.
3. Ethno-ophthalmology: Study of plants for eye ailments.

Which of the above statement(s) is/are correctly matched?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

281. The Ayurvedic system is based on the balance of three fundamental 'doshas'. These are:
(A) Earth, Water, Fire
(B) Yin, Yang, Qi
(C) Salt, Sweet, Sour
(D) Vata, Pitta, Kapha

282. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): Domestication of plants like wheat and rice was a pivotal event in human history.
Reason (R): It allowed for the development of sedentary agricultural societies.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

283. Which part of Zingiber officinale is the source of ginger?
(A) Tuber
(B) Rhizome
(C) Root
(D) Bulb

284. A traditional remedy for asthma and bronchial inflammation involves preparing a tea from the leaves of:
(A) Ocimum sanctum
(B) Jatropha curcas
(C) Lawsonia inermis
(D) Santalum album

285. In industrial production, a fermenter is NOT typically used for which of the following processes?
(A) Production of beer and wine.
(B) Mass production of antibiotics like penicillin.
(C) Clonal propagation of orchids.
(D) Production of enzymes like amylase.

286. 'Organogenesis' in plant tissue culture refers to the formation of:
(A) Protoplasts
(B) Somatic embryos
(C) Haploid cell lines
(D) Organs like shoots and roots from a callus

287. Which of the following is a key application of cryopreservation?
(A) The long-term conservation of germplasm.
(B) The rapid multiplication of plant material.
(C) The production of haploid plants.
(D) The creation of transgenic plants.

288. A major oilseed crop is:
(A) Gram
(B) Soybean
(C) Wheat
(D) Cotton

289. Which plant is associated with the production of opium, morphine, and codeine?
(A) Cannabis sativa
(B) Papaver somniferum
(C) Atropa belladonna
(D) Rauvolfia serpentina

290. The term 'Ethnomedicine' refers to:
(A) The comparative study of traditional medical systems of various cultures.
(B) The study of medicines used in ethnic restaurants.
(C) The veterinary use of medicinal plants.
(D) The commercial production of medicine from plants.

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291. Given below are two statements.
Statement I: The gel from Aloe vera leaves is a potent internal medicine for heart disease.
Statement II: The primary traditional use of Aloe vera gel is external, for soothing skin ailments and burns.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.

8. (A) The study of traditional perspectives and management of ecological relationships.
Ethnoecology examines how different cultures perceive and interact with their local ecosystems. It focuses on traditional ecological knowledge regarding resource management, climate patterns, and biodiversity conservation. By understanding these indigenous perspectives, researchers can develop more sustainable environmental policies that integrate traditional wisdom with modern conservation science, ensuring that local communities remain central to the protection of their natural heritage.

9. (A) Both A and R are true and R is the correct explanation of A.
Ethnobotany is vital for drug discovery because traditional knowledge often serves as a guide for identifying plants with bioactive properties. Many modern pharmaceuticals have been developed by scientifically investigating plant species used by indigenous healers. This traditional wisdom provides essential leads for researchers, allowing them to isolate pharmacologically active compounds that eventually become standardized treatments for various diseases in modern medicine.

10. (A) Ethnocosmetics
Ethnocosmetics is the branch of ethnobotany that focuses on how traditional societies utilize plant materials for personal hygiene and aesthetic enhancement. Many cultures use specific barks, leaves, and fruits as soaps, hair dyes, or skin treatments. Documenting these practices reveals important knowledge about natural ingredients that have been used for centuries to maintain physical appearance and protect the body from environment.

11. (D) The links between language, culture, and the local plant world.
Ethnolinguistics in the context of ethnobotany explores the profound relationship between a culture's language and its botanical environment. It examines how plant names, metaphors, and folk stories reflect a society's understanding of vegetation. This study reveals how linguistic diversity is often tied to biological diversity, as the loss of local languages frequently leads to the disappearance of specialized knowledge regarding plants.

12. (B) 2 and 3 only
Ethnobotany is a broad field documenting all human-plant interactions, not just medicinal uses. Archaeoethnobotany specifically utilizes the analysis of ancient seeds and pollen to reconstruct past plant usage. Additionally, ethnomusicology includes the study of plant materials, such as specific woods or gourds, used to construct traditional musical instruments. Together, these statements illustrate the diverse and multidisciplinary nature of ethnobotanical research.

13. (C) Ethnonarcotics
Ethnonarcotics is the sub-discipline of ethnobotany that investigates plants containing psychoactive or hallucinogenic substances used in traditional cultural and spiritual rituals. These plants are often considered sacred and are used by shamans or healers to induce altered states of consciousness. The study focuses on the cultural context, preparation methods, and perceived spiritual effects of these potent botanical agents within societies.

14. (D) Conserving traditional crop varieties and wild plant relatives.
Ethnobotany plays a critical role in preserving genetic diversity by documenting and encouraging the continued use of traditional crop varieties. Indigenous farming practices often maintain wild plant relatives that possess unique genetic traits, such as drought resistance or pest tolerance. By protecting these landraces, ethnobotanists help ensure the long-term food security and resilience of global agriculture against environmental changes.

15. (D) Statement I is false, but Statement II is true.
The Unani system of medicine originated in ancient Greece and was later developed by Arab and Persian physicians, not in Vedic India. Conversely, the homeopathic system, founded by Samuel Hahnemann, operates on the principle that substances causing symptoms in healthy people can cure similar symptoms in sick individuals. This fundamental concept is central to the practice and philosophy of modern homeopathic treatment.

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ANSWERS

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1. (B) The scientific study of the relationships that exist between peoples and plants.
Ethnobotany explores how different cultures interact with plants for food, medicine, and rituals. It bridges the gap between traditional knowledge and modern science by analyzing how humans utilize local flora. This interdisciplinary field combines botany and anthropology to document the cultural significance of plant species within various societies, ensuring the preservation of diverse biocultural practices and traditional wisdom worldwide.

2. (A) Analysis of plant remains from archaeological sites.
Archaeoethnobotany focuses on recovering and identifying plant remains from ancient human settlements to understand past diets and environments. Researchers analyze macro-remains like seeds and wood or micro-remains like pollen and phytoliths. This specialized branch provides evidence of historical plant domestication and agricultural transitions, revealing how ancient civilizations interacted with and managed their local botanical resources over centuries of development.

3. (A) Both Statement I and Statement II are true.
Ethnomedicine examines traditional medicinal practices used by cultural groups to treat various illnesses and maintain health. Ethnopharmacology is the scientific investigation of the biological activities and chemical properties of these traditional substances. Both fields are interconnected, with ethnomedicine providing the cultural context and ethnopharmacology offering the rigorous scientific validation required to understand the efficacy and safety of traditional remedies.

4. (D) Ethno-orthopaedics
Ethno-orthopaedics is a specialized sub-discipline of ethnobotany that documents traditional methods for treating skeletal injuries and bone fractures using plants. Local healers often apply specific poultices or administer decoctions believed to accelerate the healing process of bones. This field captures the unique knowledge of indigenous communities regarding the structural and medicinal properties of plants utilized for physical rehabilitation and bone repair.

5. (C) Phytochemistry
Ethnobotany encompasses various sub-disciplines that focus on human-plant interactions, such as ethnotaxonomy and ethnolinguistics. While phytochemistry studies the chemical compounds within plants, it is a branch of plant chemistry rather than a social or cultural sub-discipline of ethnobotany itself. The other listed fields specifically explore how different cultures perceive, name, and utilize plant life for cosmetics or biological classification.

6. (B) Ethnotaxonomy
Ethnotaxonomy is the study of how local or indigenous people perceive, name, and classify the plants in their environment. It highlights the differences between folk classification systems and formal scientific taxonomy. Understanding these indigenous classification systems provides insight into how cultures organize biological information based on use, morphology, or ecological roles, which is vital for preserving traditional botanical knowledge and biodiversity.

7. (A) P-4, Q-1, R-2, S-3
Ethno-gynaecology focuses on traditional knowledge regarding childbirth and women's health, while ethnotoxicology studies plant-based poisons. Ethnopaediatrics deals with traditional remedies for children's diseases, and ethno-ophthalmology explores treatments for eye ailments. Each sub-discipline represents a specific area of indigenous medical expertise, demonstrating the comprehensive nature of traditional botanical knowledge in addressing various health needs within a community through specialized plant applications.

43. (B) An adaptogen and nervine tonic
Withania somnifera, popularly known as Ashwagandha, is valued in ethnobotany as a powerful adaptogen and nervine tonic. It helps the body manage stress, enhances physical energy, and supports the nervous system. The name Ashwagandha refers to the horse-like smell of its roots and the belief that consuming the plant provides the strength and vitality of a horse, promoting longevity and well-being.

44. (C) Rhizome
Ginger is the aromatic, pungent underground stem or rhizome of the Zingiber officinale plant. Its unique flavour and medicinal properties are due to volatile oils and phenolic compounds like gingerol and shogaol found within the rhizome. Ethnobotanically, it is used worldwide as a spice and a remedy for digestive issues, nausea, and respiratory conditions, making it an essential medicinal food.

45. (D) Strychnos nux-vomica
Strychnine is a highly toxic alkaloid extracted from the dried seeds of the Strychnos nux-vomica tree. Historically used in minute doses as a stimulant and to treat various ailments, it is now primarily used as a rodenticide due to its lethal effect on the central nervous system. Its inclusion in traditional medicine required extreme caution and specialized purification processes to prevent poisoning.

46. (A) Eugenia jambolana
Eugenia jambolana, commonly known as Jamun or Indian Blackberry, is an important ethnobotanical species whose seeds are traditionally used to manage diabetes. The seeds contain compounds like jamboline that help prevent the conversion of starch into sugar, thereby controlling blood glucose levels. The fruit is also highly valued for its nutritional content and its role in traditional diets as a healthy snack.

47. (B) Menthol, used in balms and confectionary.
Mentha arvensis, or wild mint, is the primary commercial source of natural menthol. Menthol is extracted from the essential oil of the leaves and is widely used in traditional balms, lozenges, and confectionary for its cooling sensation and aromatic properties. It is ethnobotanically significant for treating headaches, respiratory congestion, and digestive issues, providing a refreshing and therapeutic effect for various common ailments.

48. (B) Allium cepa
Allium cepa is the botanical name for the common onion, which is one of the most widely cultivated vegetables. Beyond its culinary uses, it is a staple in folk medicine for treating wounds, infections, and respiratory issues. Onions contain various sulfur compounds and antioxidants that provide health benefits, making them a significant species in both daily nutrition and traditional healing practices worldwide.

49. (A) Terminalia arjuna
The traditional Ayurvedic Triphala formula specifically contains the fruits of Terminalia chebula, Terminalia bellerica, and Emblica officinalis. While Terminalia arjuna is an important medicinal tree used for heart health, it is not a constituent of the Triphala mixture. This distinction is important because Triphala is specifically formulated as a digestive and rejuvenating tonic, whereas Arjuna is primarily used as a cardiotonic.

50. (C) P-3, Q-4, R-1, S-2
Specific plant parts are utilized for their unique chemical compositions. Rauvolfia serpentina provides medicinal roots, while Papaver somniferum yields latex from its unripe fruit capsules. Eugenia aromatica is known for its dried flower buds (cloves), and Santalum album is prized for its aromatic heartwood. These examples demonstrate the diverse sources of botanical products used in traditional medicine, cosmetics, and culinary spices.

51. (C) Holarrhena antidysenterica
A decoction made from the bark of Holarrhena antidysenterica is a classic traditional treatment for amoebic dysentery. The bark contains potent alkaloids that effectively combat the intestinal parasites responsible for the infection. This plant is a cornerstone of tropical ethnopharmacology, offering a reliable natural remedy for severe gastrointestinal issues where modern medicines may be inaccessible or where traditional healing is preferred.

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16. (B) Totem
A totem is a plant or animal species that serves as a sacred emblem for a specific clan or family within a traditional society. It represents a deep spiritual connection between the group and the natural world. Because the totem is revered, members of the clan are often prohibited from harming or consuming it, which effectively promotes the conservation of that species.

17. (B) Providing new models for sustainable agriculture and conservation.
Ethnobotany contributes to modern society by offering insights into sustainable land management and agricultural practices developed over generations. Traditional knowledge of crop rotation, polyculture, and natural pest control provides valuable alternatives to industrial farming methods. By integrating these time-tested techniques, modern science can develop more resilient food systems and effective conservation strategies that protect both biological and cultural diversity.

18. (A) A cultural or religious prohibition against using or harming a specific plant.
A plant taboo is a social or religious rule that restricts or forbids the use, harvest, or consumption of a particular plant species. These prohibitions are often rooted in spiritual beliefs or the perceived sacredness of the plant. Such cultural restrictions play a vital role in traditional conservation, as they prevent the overexploitation of certain species and help maintain ecological balance.

19. (C) Ayurvedic system
The Ayurvedic system of medicine is based on the fundamental concept of three biological energies or humors known as Vata, Pitta, and Kapha. Health is achieved when these three doshas are in perfect balance within the body. Practitioners use various combinations of herbs, diet, and lifestyle changes to correct imbalances, making it one of the oldest comprehensive health systems.

20. (A) Both A and R are true and R is the correct explanation of A.
Tribal communities significantly contribute to wildlife protection through cultural beliefs that deify nature. Practices like maintaining sacred groves or respecting totems create protected habitats where plants and animals can thrive without human interference. These traditional conservation methods are often more effective than formal laws in certain regions because they are deeply integrated into the spiritual and social lives of people.

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21. (A) Plant domestication
Plant domestication is the long-term process through which human communities select and cultivate wild plants with desirable traits, such as larger seeds or better taste. Over generations, these selected plants undergo genetic changes that make them distinct from their wild ancestors. This foundational agricultural process, driven by traditional knowledge, has led to the vast diversity of crops we rely on today.

22. (C) Reveals the cultural significance and context of the plant's use.
Folktales and myths are essential to ethnobotanical study because they explain how a plant became integrated into a community's life. These stories often provide clues about a plant's perceived medicinal properties, sacred status, or historical importance. By studying these narratives, researchers gain a deeper understanding of the cultural values and social structures that surround the practical use of botanical resources.

23. (A) Aconitum napellus
Aconitum napellus, commonly known as monkshood, is famous for containing extremely potent alkaloids like aconitine. While it is used in highly controlled doses in some traditional medicine systems for its analgesic properties, it is primarily known for its severe neurotoxicity and cardiotoxicity. Due to its lethal nature, it requires expert handling and is often associated with ancient poisons and ritualistic usage.

24. (B) 2 and 3 only
Allopathic medicine frequently utilizes plant-derived compounds, such as aspirin and morphine, meaning it does not exclusively use synthetic substances. However, folklore remains a valuable source for identifying new medicinal leads, and the use of plants in similes and metaphors highlights their deep cultural integration. These elements demonstrate that traditional knowledge and linguistic expressions

are vital for understanding the human-plant relationship.

25. (C) A medicine for heart and infection.
Allium sativum, commonly known as garlic, has been used for millennia in traditional medicine as both a preventative and curative agent. It is ethnobotanically valued for its ability to support cardiovascular health and its potent antimicrobial properties. Compounds like allicin contribute to its efficacy in treating infections and maintaining heart function, making it a staple in various folk medicine systems.

26. (A) Atropine
Atropine is a tropane alkaloid extracted from the nightshade plant, Atropa belladonna, which has significant applications in modern medicine. In ophthalmology, it is primarily used as a mydriatic agent to dilate the pupils for diagnostic examinations. The compound works by blocking certain nerve impulses, allowing eye specialists to examine the retina and other internal structures more clearly during clinical procedures.

27. (B) P-4, Q-3, R-1, S-2
Aloe vera is widely recognized for its soothing gel used in skin care, while Azadirachta indica, or Neem, is valued as a pesticide and medicinal herb. Butea monosperma is famously called the Flame of the Forest due to its bright flowers, and Cassia fistula, the Indian Laburnum, is traditionally used as a gentle but effective purgative in traditional medicine.

28. (D) A primary source of rubber.
Cannabis sativa is a multi-purpose plant valued ethnobotanically for its strong bast fibres used in making hemp rope and textiles. Its seeds provide a nutritious oil, and its resinous parts contain psychoactive compounds used in traditional rituals and medicine. However, it is not a source of rubber, which is primarily obtained from the latex of the Hevea brasiliensis tree.

29. (A) Both Statement I and Statement II are true.
Emblica officinalis, known as Amla, is a powerhouse of Vitamin C and a central herb in Ayurvedic medicine. It is traditionally used to treat various conditions, including jaundice and digestive issues, due to its antioxidant and laxative properties. Both statements accurately reflect the plant's nutritional value and its diverse roles in maintaining health and treating specific ailments in traditional systems.

30. (C) Eugenia aromatica
The spice clove is derived from the dried, unopened flower buds of the tropical evergreen tree Eugenia aromatica. Ethnobotanically, cloves are prized for their strong aromatic flavour and medicinal properties, particularly as a local anaesthetic for toothaches. The essential oil extracted from these buds contains eugenol, which provides antiseptic and analgesic benefits, making it an essential component of traditional medicine.

31. (D) Dysentery
Holarrhena antidysenterica is a significant medicinal plant traditionally used to treat gastrointestinal disorders. As its botanical name suggests, its bark and seeds contain alkaloids like conessine that are highly effective against the causative agents of amoebic dysentery. This plant is a primary remedy in many indigenous cultures for managing severe diarrhea and intestinal infections, providing a natural alternative for digestive health.

32. (A) The production of biodiesel.
Jatropha curcas has gained global attention because its seeds contain high amounts of non-edible oil that can be processed into biodiesel. Ethnobotanically used for fences and traditional medicine, it is now viewed as a sustainable energy source. The plant's ability to grow in poor soils and arid conditions makes it an ideal candidate for biofuel production without competing with food crops.

33. (B) Lawsonia inermis
Henna is a natural red dye obtained from the powdered leaves of the Lawsonia inermis plant. It is used extensively in ethnocosmetics for body art, known as mehndi, and as a natural hair dye. Beyond its aesthetic uses, henna is valued in traditional medicine for its cooling effect on the skin and its antifungal properties, making it a culturally significant species.

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34. (B) Both A and R are true but R is not the correct explanation of A.
Ocimum sanctum, or Tulsi, is revered as a sacred plant in India and is also scientifically recognized for its antimicrobial and adaptogenic benefits. While both facts are true, the reason it is considered sacred is rooted in spiritual and religious traditions rather than solely because of its medicinal properties. Its dual role as a religious icon and healer demonstrates its deep cultural significance.

35. (C) Piper nigrum
Piper nigrum, commonly known as black pepper, is often referred to as the King of Spices due to its historical economic importance and global culinary popularity. Ethnobotanically, it is used as a biostimulant and a digestive aid. The presence of piperine enhances the bioavailability of other nutrients and medicines, making it a critical ingredient in many traditional polyherbal formulations for improved health.

36. (D) The heartwood
The heartwood of the Pterocarpus marsupium tree is traditionally used to make tumblers for diabetic patients. When water is stored in these tumblers overnight, it absorbs bioactive compounds like epicatechin from the wood. Drinking this water is believed to help regulate blood sugar levels. This unique practice showcases the ingenious use of specific plant parts in traditional healthcare for managing chronic conditions.

37. (D) Opium
Opium is a narcotic substance obtained from the dried milky latex of the unripe seed capsules of the poppy plant, Papaver somniferum. This latex contains several potent alkaloids, including morphine, codeine, and thebaine, which are highly valued for their analgesic and sedative properties. While used extensively in traditional and modern medicine for pain management, opium carries a significant risk of addiction.

38. (B) 2 and 3 only
Rauvolfia serpentina is not a source of rubber, but its roots are famous for providing the alkaloid reserpine. This compound has been used traditionally and in modern medicine to treat high blood pressure and mental disorders like insanity. The plant's importance lies in its powerful pharmacological effects on the nervous and cardiovascular systems, making it a cornerstone of both traditional and modern therapeutics.

39. (C) As a potent laxative.
Castor oil, extracted from the seeds of Ricinus communis, is a well-known traditional remedy used primarily as a potent stimulant laxative to treat constipation. It contains ricinoleic acid, which induces bowel movements. While the seeds themselves are highly toxic due to the protein ricin, the processed oil is safe for medicinal use and has been a staple in folk medicine for centuries.

40. (A) Santalum album
Sandalwood is obtained from the aromatic heartwood of the Santalum album tree. It is highly prized ethnobotanically for its essential oil and fragrant wood, used in religious ceremonies, perfumes, and traditional skin care. The tree is a hemi-parasite, requiring host plants for nutrients. Its slow growth and high demand for its cooling and aromatic properties have made it one of the world's most valuable trees.

41. (A) Both Statement I and Statement II are true.
Triphala is a classic Ayurvedic formulation consisting of equal parts of the dried fruits of three different medicinal trees. These include Terminalia chebula (Haritaki), Terminalia bellerica (Bibhitaki), and Emblica officinalis (Amla). Together, they act as a balanced internal cleanser and rejuvenator, supporting digestion, detoxification, and immune health. Both statements correctly describe the composition and botanical sources of this famous traditional remedy.

42. (D) Terminalia arjuna
Terminalia arjuna is traditionally known as the guardian of the heart in Ayurvedic medicine. The bark of this tree contains glycosides and minerals like calcium that strengthen the heart muscles and improve cardiovascular function. It is used as a cardiotonic to treat conditions such as heart failure and hypertension, representing one of the most effective traditional botanical treatments for heart-related ailments.

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61. (D) Diuretic
Diuretic plants are traditionally used to treat urogenital problems by increasing the production and excretion of urine. This helps flush out toxins and bacteria from the urinary tract and reduces fluid retention. Many traditional remedies for kidney stones and urinary infections rely on these diuretic properties to promote better renal health and alleviate discomfort associated with various urinary tract conditions.

62. (B) Ricinus communis (castor oil application)
In traditional medicine, the external application of castor oil from Ricinus communis is a common supportive therapy for rheumatism and joint pain. The oil contains ricinoleic acid, which has significant anti-inflammatory and analgesic properties. Massaging the oil onto affected areas helps reduce swelling and stiffness, providing relief to those suffering from chronic inflammatory conditions like arthritis and rheumatism.

63. (C) Diabetes
The traditional use of Pterocarpus marsupium wood tumblers is specifically aimed at managing diabetes. When water is left in the tumbler, it leaches out bioactive compounds that help regulate blood sugar levels. This unique delivery method is a well-known ethnobotanical practice, demonstrating how traditional knowledge utilizes the chemical properties of specific woods to provide ongoing treatment for chronic metabolic disorders.

64. (D) Cancer
While traditional medicine provides remedies for malaria, tuberculosis, and some skin cancers, comprehensive treatment for advanced cancer is generally not the primary focus of common medicinal plant usage in traditional systems. These systems often excel at managing common infections and chronic conditions, but modern oncological treatments are typically required for the complex pathology and management associated with most malignant cancers.

65. (A) Totipotency
Totipotency is the inherent ability of a single plant cell to divide and differentiate into all the different cell types required to form a complete, functional organism. This principle is the cornerstone of plant tissue culture and biotechnology. It allows scientists to regenerate entire plants from small tissue segments or individual cells, facilitating mass propagation and the development of genetically modified varieties.

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66. (B) To prevent microbial contamination of the culture.
Aseptic and sterilization techniques are critical in plant tissue culture because the nutrient-rich medium used to grow plant cells also supports the rapid growth of bacteria and fungi. Contamination can quickly overwhelm the plant tissue, leading to culture failure. Ensuring a sterile environment allows the plant cells to grow and differentiate without competition or damage from harmful microorganisms.

67. (B) A small piece of tissue or organ used to initiate a culture.
An explant is any small portion of a plant, such as a leaf segment, root tip, or bud, that is removed and placed onto a nutrient medium to start a tissue culture. The success of the culture depends on the explant's ability to regenerate through totipotency. Choosing the right tissue as an explant is essential for achieving specific goals like cloning.

68. (A) Both A and R are true and R is the correct explanation of A.
Meristem culture is an effective technique for producing virus-free plants because the apical meristem is usually not infected by viruses, even in a diseased plant. This is because the rapid cell division in the meristem outpaces the movement of viruses through the developing vascular tissues. By culturing this healthy tissue, scientists can regenerate completely disease-free clones of valuable varieties.

69. (D) Anther culture
Anther culture involves the laboratory cultivation of pollen grains or anthers to produce haploid plants, which contain only one set of chromosomes. These haploid plants are highly valuable in plant breeding because their chromosome number can be doubled to create homozygous diploid lines quickly. This technique significantly accelerates the process of developing new varieties with stable and desirable genetic traits.

52. (A) Both A and R are true and R is the correct explanation of A.
Azadirachta indica, or Neem, is widely used for skin diseases because its leaves and seeds are rich in bioactive compounds with antibacterial and antifungal properties. These natural chemicals effectively treat infections like scabies and eczema while promoting healing. Both statements are accurate, as the plant's proven biological activities provide the scientific basis for its extensive use in traditional dermatology.

53. (C) The whole plant or leaves of Phyllanthus niruri or Emblica officinalis.
Phyllanthus niruri and Emblica officinalis are traditionally used to treat jaundice because they possess hepatoprotective properties that help restore liver function. These plants aid in the detoxification of the liver and reduce bilirubin levels. Using these botanical remedies is a common practice in many traditional medicine systems to manage hepatitis and other liver-related disorders effectively and naturally.

54. (B) Azadirachta indica
A paste made from the leaves of Azadirachta indica (Neem) is a highly effective traditional remedy for skin ailments such as eczema, psoriasis, and acne. The plant's potent antiseptic and anti-inflammatory properties help reduce itching, redness, and infection. Neem's long history of use in skin care reflects its reliability as a natural treatment for maintaining healthy skin across many cultures.

55. (A) Both Statement I and Statement II are true.
Terminalia arjuna is a well-regarded traditional remedy for heart diseases because its bark acts as a powerful cardiotonic. The bioactive constituents strengthen the heart muscles and improve blood flow, supporting overall cardiovascular health. Both statements are correct, as they describe the traditional usage and the physiological mechanism by which the plant provides therapeutic benefits to the heart and circulation.

56. (D) Azadirachta indica
Azadirachta indica, or Neem, is traditionally utilized as a blood purifier in many folk medicine systems. Consuming its bitter leaves or extracts is believed to remove toxins from the body and improve skin health from within. This practice is rooted in the belief that many skin and systemic issues arise from impurities in the blood, which Neem's antimicrobial properties help eliminate.

57. (A) Anthelmintic
An anthelmintic is a substance, often derived from plants, used to expel or destroy parasitic worms from the body. Many traditional societies use specific seeds, barks, or roots to treat intestinal worm infestations. These botanical preparations work by either killing the parasites or paralyzing them, allowing them to be naturally expelled, thus providing a critical solution for maintaining gastrointestinal health.

58. (C) The leaves of Ocimum sanctum (Tulsi).
The leaves of Ocimum sanctum, or Tulsi, are traditionally used to treat bronchial inflammation, asthma, and common colds. Tulsi contains essential oils and compounds that act as expectorants and anti-inflammatory agents, helping to clear the respiratory tract and ease breathing. This plant is a staple in household medicine for its accessibility and effectiveness in managing various respiratory conditions naturally.

59. (A) Holarrhena antidysenterica
Holarrhena antidysenterica is the plant most directly associated with treating amoebic dysentery in traditional medicine. Its bark and seeds are rich in conessine and other alkaloids that specifically target the parasites in the gut. Its prominent role is reflected in its botanical name, highlighting its status as a primary remedy for severe intestinal infections in several indigenous cultures and medical systems.

60. (B) 1 and 2 only
Traditional treatments for piles often use laxative plants like Cassia fistula, and leucoderma is treated with photosensitizing plants like Psoralea corylifolia. However, there are many documented traditional remedies for tuberculosis using plants like Adhatoda vasica. Therefore, while the first two statements accurately reflect traditional practices, the third statement is incorrect as traditional medicine has numerous documented approaches to respiratory infections.

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(D) Statement I is false, but Statement II is true.

292. Match List I with List II and select the correct answer using the codes given below.
List I: (Plant)
P. Withania somnifera
Q. Terminalia arjuna
R. Azadirachta indica
S. Papaver somniferum
List II: (Primary Traditional Use)
1. Cardiotonic
2. Analgesic (source of opium)
3. Adaptogen (nervine tonic)
4. Insecticide, skin care
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-1, S-3

293. The term 'explants' in plant tissue culture is best defined as:
(A) The glass vessel used for culture.
(B) The agar used to solidify the medium.
(C) A piece of tissue placed into a nutrient medium to start a culture.
(D) The plantlet that develops at the end of the culture period.

294. A researcher studying the names and classification of plants used by a specific indigenous community is working in the field of:
(A) Ethnopharmacology
(B) Ethnoecology
(C) Archaeoethnobotany
(D) Ethnotaxonomy

295. The primary purpose of adding growth regulators like auxins and cytokinins to a plant tissue culture medium is to:
(A) Direct cell division and differentiation.
(B) Provide an external energy source.
(C) Maintain the pH levels of the medium.
(D) Prevent all microbial contamination.

296. The heartwood of Pterocarpus marsupium is traditionally used in the management of diabetes. What is the common method of its use?
(A) Making a paste of the wood and applying it externally.
(B) Drinking water that has been stored in a tumbler made from the wood.
(C) Inhaling the smoke from burning the wood.
(D) Consuming the flowers of the tree.

297. Consider the following statements about applied botany:
1. A transgenic plant contains genes from a different species, introduced by genetic engineering.
2. Phytoremediation is the use of plants to clean up environmental pollutants.
3. Somatic hybridization is another term for sexual reproduction in plants.
Which of the above statement(s) is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

298. In India, which plant is revered as sacred (Tulsi) and is used widely in households for its medicinal properties, especially for coughs and colds?
(A) Azadirachta indica
(B) Ocimum sanctum
(C) Aloe vera
(D) Withania somnifera

299. The following question consists of two statements — Assertion (A) and Reason (R).
Assertion (A): The technique of cryopreservation uses liquid nitrogen.
Reason (R): Liquid nitrogen provides an ultra-low temperature (-196°C) that arrests all metabolic activities and prevents ice crystal damage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

300. Which of these is NOT a cereal?
(A) Wheat
(B) Gram
(C) Rice
(D) Maize

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70. (A) Organogenesis
Organogenesis in plant tissue culture is the process where organs such as shoots, roots, or flowers are developed directly from an explant or an undifferentiated mass of cells called a callus. This development is controlled by adjusting the concentrations of plant hormones like auxins and cytokinins in the culture medium. It is a vital step in regenerating complete plants from cultured tissues.

71. (A) P-3, Q-4, R-1, S-2
Totipotency is the potential of a cell to form a whole plant, while an explant is the tissue used to start a culture. Anther culture is specifically used for producing haploid plants, and cryopreservation involves storing plant material in liquid nitrogen for long-term conservation. Understanding these terms is essential for mastering the various techniques and applications of modern plant biotechnology.

72. (C) The fusion of protoplasts from two different plant species in vitro.
Somatic hybridization is a technique where the cell walls of two different plant species are removed to create protoplasts, which are then fused together in a laboratory. This process allows scientists to create hybrid plants between species that cannot naturally crossbreed. It is a powerful tool for transferring desirable traits like disease resistance or stress tolerance across distant taxonomic boundaries.

73. (B) Ultra-low temperatures, typically in liquid nitrogen (-196°C)
Cryopreservation is the long-term storage of plant germplasm at ultra-low temperatures, usually in liquid nitrogen at -196°C. At this temperature, all metabolic and biological activities of the cells are completely arrested, allowing the tissues to be preserved for many years without genetic change. This technique is essential for the conservation of endangered species and valuable agricultural genetic resources.

74. (C) Statement I is true, but Statement II is false.
Transgenic plants are indeed created through recombinant DNA technology to possess specific desirable traits. However, phytoremediation is the use of plants to clean up environmental contaminants, not to produce pharmaceuticals. The production of drugs using transgenic plants is known as molecular farming. Therefore, the first statement accurately defines transgenic organisms, while the second statement confuses two different biotechnological applications.

75. (C) Phytoremediation
Phytoremediation is an environmentally friendly technology that utilizes plants and their associated microbes to remove, stabilize, or destroy contaminants in soil, water, and air. This process exploits the natural ability of certain species to absorb heavy metals and degrade organic pollutants. It offers a cost-effective and sustainable alternative to traditional mechanical cleanup methods, helping to restore ecological balance in industrially polluted areas.

76. (D) Large-scale production of uniform, disease-free plants.
A major application of plant tissue culture is micropropagation, which allows for the rapid, large-scale production of genetically identical and disease-free plantlets. This technique is widely used in agriculture and horticulture to produce high-quality planting material for crops like bananas and orchids. It ensures that farmers receive uniform plants with superior traits, increasing overall productivity and reducing losses from diseases.

77. (A) Provide a controlled environment for the growth of microorganisms to produce a desired product.
An industrial fermenter, or bioreactor, is a large vessel designed to provide optimal conditions for the growth of microorganisms. It allows for the precise control of temperature, pH, aeration, and nutrient supply. These controlled environments are essential for the mass production of valuable biological products such as antibiotics, enzymes, and vaccines, ensuring high yields and consistent product quality.

78. (D) 1, 2 and 3
Embryo culture helps save hybrid embryos from abortion, while somatic hybridization requires removing cell walls to create protoplasts for fusion. Transgenic technology allows for the introduction of specific traits like pest resistance. All three statements correctly describe important techniques in applied botany that enhance

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149. (A) Selecting and propagating wild plants with desirable traits over generations.
Plant domestication by tribal communities is a gradual process of artificial selection, where individuals with the best traits, like larger fruits or disease resistance, are repeatedly chosen and replanted. Over thousands of years, this practice has transformed wild plants into the productive crops we use today. This indigenous process of genetic improvement through observation and cultivation is the foundation of all modern global agriculture and food security.

150. (D) Both A and R are false.
Folklore and folktales are highly relevant to ethnobotany because they contain valuable cultural and practical information about plants. While they are narratives, they often reflect generations of observation and traditional knowledge regarding a plant's uses and importance. Scientists use these stories as vital clues for identifying plants with unique medicinal or ecological properties, making them a significant and verifiable resource for ethnobotanical research and discovery.

151. (C) Withania somnifera
Withania somnifera is frequently called Indian Ginseng because, like true Ginseng, it is used as a powerful adaptogen in traditional medicine to enhance physical and mental energy. It helps the body adapt to stress, improves vitality, and supports the immune system. Its status as a premier rejuvenating herb in Ayurveda has led to its comparison with other famous tonic plants used in different cultures worldwide.

152. (A) It allows for the control of parameters like temperature, pH, and oxygen.
A key feature of a bioreactor or fermenter is its ability to precisely control environmental parameters such as temperature, pH, and dissolved oxygen levels. This control ensures that the microorganisms or cells being cultured grow at their optimal rate and produce the maximum amount of the desired product. Such precision is essential for the industrial-scale production of high-quality pharmaceuticals, enzymes, and other biological materials.

153. (D) Phytoextraction
Phytoextraction is a phytoremediation technique where plants absorb toxic heavy metals like lead and arsenic from the soil through their roots and accumulate them in their stems and leaves. Once the plants have matured, they are harvested and safely disposed of, effectively removing the contaminants from the environment. This method provides a natural and cost-effective way to clean up polluted lands using the biological capabilities of specific plants.

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154. (B) Rauvolfia serpentina and Atropa belladonna
Rauvolfia serpentina is the source of reserpine, used in allopathy to treat hypertension, while Atropa belladonna provides atropine for pupil dilation. These two plants illustrate the critical role of botanical sources in modern medicine. Their alkaloids have been isolated and standardized to create reliable pharmaceutical treatments for serious cardiovascular and neurological conditions, demonstrating how traditional medicinal leads have shaped contemporary medical practice and drug development.

155. (A) Both Statement I and Statement II are true.
Cryopreservation is a sophisticated technique for the long-term conservation of plant genetic resources at the temperature of liquid nitrogen (-196°C). At this ultra-low temperature, all biological activities are paused, ensuring that the plant tissues remain viable and genetically stable for many years. Both statements accurately describe this essential tool for preserving global biodiversity and ensuring the future availability of valuable plant varieties and endangered species.

156. (D) Differentiation
Differentiation in tissue culture is the process where undifferentiated callus cells become specialized to form specific organs like shoots or roots. This biological transformation is triggered by specific ratios of plant hormones in the growth medium. Understanding and controlling differentiation is key to successfully regenerating whole plants from small tissue samples, allowing for the rapid multiplication of superior varieties through various biotechnological and agricultural applications.

88. (B) Simile
The phrase "as strong as an oak" is a plant-based simile, which uses a comparison with "as" or "like" to highlight a specific quality. This linguistic expression reflects how deeply plants are integrated into human culture and communication. Similes like this draw upon the well-known characteristics of plants, such as the oak's strength, to convey descriptive meaning in everyday language.

89. (A) Aloe vera - Timber production
Aloe vera is ethnobotanically valued for its soothing gel used in skin care and medicine, not for timber production. Timber is obtained from large woody trees, whereas Aloe vera is a succulent plant. The other pairings correctly identify Cannabis for fibre, Jatropha for biodiesel, and Lawsonia for dye, illustrating the diverse and specific uses of plants in traditional and modern societies.

90. (A) Both A and R are true and R is the correct explanation of A.
Plants in mythology are highly relevant to ethnobotany because myths often contain valuable information about a plant's perceived powers and cultural significance. These stories explain why certain plants are considered sacred or why they are used in specific rituals. By analyzing mythology, ethnobotanists can uncover the deep-seated cultural beliefs that have protected and managed various plant species for generations.

91. (A) P, Q, R, S
Creating a transgenic plant begins with identifying and isolating the specific gene of interest. This gene is then inserted into plant cells through transformation. Next, the successfully transformed cells are selected using markers, and finally, a whole plant is regenerated from these selected cells through tissue culture. This chronological sequence is the standard procedure used in modern plant biotechnology laboratories.

92. (B) Treating burns and soothing skin irritations.
The clear gel found inside the leaves of Aloe vera is traditionally used for its cooling and healing properties on the skin. It is a common remedy for minor burns, sunburns, and various skin irritations due to its anti-inflammatory and moisturizing effects. Its wide availability and effectiveness have made it one of the most popular natural skin care ingredients worldwide.

93. (D) Butea monosperma
Butea monosperma is commonly known as the Flame of the Forest due to its striking, bright orange-red flowers that bloom in clusters. These flowers are traditionally used to make a natural yellow or orange dye, particularly for the Holi festival in India. The tree is also valued ethnobotanically as a host for the lac insect and for its medicinal bark.

94. (A) The pulp inside the fruit pods
The medicinal purgative properties of Cassia fistula, or the Golden Shower tree, are primarily found in the black, sweet-smelling pulp that surrounds the seeds inside its long fruit pods. This pulp is used in traditional medicine as a gentle and effective laxative. Its use is widespread in various cultures, providing a natural remedy for constipation and other digestive issues.

95. (C) Ayurveda
Emblica officinalis, or Amla, is a cornerstone of the Ayurvedic system of medicine. It is highly valued for its rejuvenating and immunomodulatory properties, often being used as a primary ingredient in formulas like Chyawanprash. Amla's high Vitamin C content and antioxidant benefits make it essential for promoting longevity, improving digestion, and strengthening the body's natural defenses against various diseases.

96. (B) 1 and 2 only
Terminalia chebula is a key component of the Ayurvedic Triphala formulation and is well-known for its laxative and astringent properties. However, it is not the source of sandalwood oil, which comes from the Santalum album tree. Haritaki, as it is known in India, is highly respected in traditional medicine for its diverse therapeutic benefits, often being called the King of Medicines.

97. (D) Wooden furniture
Microbial fermentation is an industrial process used to produce biological products like antibiotics, bioethanol, and yoghurt. These products are created by microorganisms in a

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115. (C) Statement I is true, but Statement II is false.
The heartwood of Pterocarpus marsupium is traditionally used to manage diabetes, often by drinking water stored in tumblers made from it. However, the drug reserpine is obtained from the roots of Rauvolfia serpentina, not from Pterocarpus. Therefore, while the first statement accurately describes a common traditional practice, the second statement incorrectly attributes the source of an important alkaloid to the wrong plant species.

116. (D) Papaver somniferum
The alkaloids morphine and codeine are powerful analgesics derived from the dried latex of the Papaver somniferum (opium poppy) capsule. These compounds are essential in modern medicine for managing severe pain. Their discovery and extraction from the poppy plant represent a major milestone in pharmacology, as they remain some of the most effective and widely used pain-relieving substances in clinical practice today.

117. (B) The plant is a primary source for natural rubber.
Ricinus communis is the source of castor oil, which is a powerful purgative and an external treatment for rheumatic pain. Its seeds are also notoriously toxic due to the presence of the protein ricin. However, it is not a source of natural rubber, which comes from the latex of the Hevea brasiliensis tree. This distinction is vital for understanding the different economic and medicinal roles of these plants.

118. (A) Heart ailments
The bark of Terminalia arjuna is one of the most respected traditional remedies for heart ailments in Ayurvedic medicine. It contains bioactive compounds that strengthen the heart muscle and improve its efficiency. Ethnobotanical use of this bark for cardiovascular support is backed by centuries of practice and modern research, highlighting its importance as a natural cardiotonic for treating various circulatory and cardiac conditions.

119. (B) Ocimum sanctum
A patient with a dry cough and breathing difficulty is most likely being recommended Ocimum sanctum, or Tulsi. This plant is traditionally valued for its soothing effect on the respiratory tract and its anti-inflammatory properties. Chewing its leaves or drinking its decoction is a common household remedy for clearing congestion and providing relief from bronchial irritation and cold symptoms in many cultures.

120. (C) Photosensitizing compounds
Psoralens are photosensitizing compounds found in certain plants, such as Psoralea corylifolia, used traditionally to treat leucoderma. When applied to the skin and exposed to ultraviolet light, these compounds stimulate the production of melanin in the white patches. This traditional method utilizes the interaction between plant chemistry and light to restore skin pigmentation, illustrating a sophisticated understanding of botanical properties in folk dermatology.

121. (D) To rescue hybrid embryos from incompatible crosses.
Embryo culture is a vital technique in plant breeding used to rescue hybrid embryos that would otherwise abort before reaching maturity due to genetic incompatibility between parent species. By removing the young embryo and growing it on a sterile nutrient medium, scientists can produce unique hybrids. This method allows for the creation of new plant varieties with combined desirable traits that are impossible to achieve naturally.

122. (B) P-4, Q-3, R-1, S-2
Holarrhena antidysenterica is the primary remedy for amoebic dysentery, while Terminalia arjuna is used for heart disease. Rauvolfia serpentina is famous for treating high blood pressure, and Azadirachta indica, or Neem, is a staple for skin diseases. Each of these plants represents a cornerstone of traditional medicine, providing effective natural solutions for specific health conditions based on their unique chemical properties and historical usage.

123. (C) The study of plants that are of economic or commercial value to humans.
Economic Botany focuses on the study of plants that provide direct material benefits to humans, such as food, fibres, fuels, and medicines. It examines how these botanical resources are utilized in industry and commerce to support

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106. (D) Documenting and conserving diverse biocultural systems.
A primary objective of ethnobotanical research is to document and conserve the complex relationships between people and plants. This involves protecting both biological diversity and the cultural knowledge associated with it. Rather than focusing solely on commercialization, ethnobotanists work to ensure that indigenous wisdom is preserved for future generations and that the benefits of using this knowledge are shared fairly with the communities.

107. (A) Cardiovascular and central nervous systems
The alkaloids found in Aconitum napellus, especially aconitine, are powerful toxins that primarily affect the cardiovascular and central nervous systems. Ingestion leads to severe heart arrhythmias and paralysis of the nervous system, which can be fatal. This extreme toxicity is why the plant must be handled with immense caution and is historically associated with both traditional poisons and highly specialized medicines.

108. (B) The modified leaves forming the bulb
The edible part of Allium cepa, the common onion, is a bulb composed of thickened, fleshy leaf bases that store nutrients for the plant. These modified leaves provide the characteristic layers and flavour of the onion. This structure allows the plant to survive adverse conditions by storing energy, which humans have utilized as a staple food source for thousands of years.

109. (A) Both A and R are true and R is the correct explanation of A.
Garlic (Allium sativum) has a long history in folk medicine because it contains sulfur compounds like allicin that provide significant health benefits. These compounds have proven antibacterial, antifungal, and cardiovascular-supporting effects. Scientific research into these chemical constituents explains why garlic has been traditionally used to treat infections and maintain heart health, validating the long-standing observations of various cultural medical practices.

110. (D) Dilate their pupils for cosmetic effect.
The name 'belladonna' refers to the historical practice where women used extracts from the Atropa belladonna plant to dilate their pupils, which was considered a sign of beauty. The plant contains atropine, which acts as a mydriatic by relaxing the eye muscles. While this gave the desired cosmetic effect, it also caused blurred vision and other side effects due to the plant's toxicity.

111. (B) Gossypium hirsutum
Gossypium hirsutum, a species of cotton, is primarily grown as a major industrial crop for the production of textile fibre. While many other plants like Neem or Ashwagandha are famous for their medicinal properties, cotton is valued for the natural fibres surrounding its seeds. These fibres are essential to the global clothing industry, making cotton one of the most economically important non-food crops.

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112. (B) 2 and 3 only
Ethno-ophthalmology deals with traditional treatments for eye diseases, and ethno-orthopaedics focuses on plant-based remedies for skeletal injuries. However, ethno-gynaecology concerns women's reproductive health and childbirth, not veterinary purposes. Understanding these sub-disciplines is crucial for appreciating the specialized branches of traditional botanical knowledge that address specific aspects of human health and physical well-being across different cultures.

113. (D) Jatropha curcas
Jatropha curcas is significant because its seeds produce a high-quality, non-edible oil that is a promising source for biofuel. This oil can be converted into biodiesel, providing a renewable energy alternative. Because the oil is not suitable for human consumption, using Jatropha for fuel does not directly compete with food supplies, making it an attractive option for sustainable energy production on marginal lands.

114. (A) Black Pepper (Piper nigrum)
Piper nigrum, or black pepper, is famously known as the King of Spices due to its historical economic value and global usage. It was once so valuable that it was used as currency and drove early maritime exploration. Ethnobotanically, it is prized not only for its pungent flavour in cooking but also for its medicinal role as a biostimulant that enhances the efficacy of other herbs.

plant breeding, genetic modification, and the development of superior crop varieties for modern agricultural needs.

79. (C) Soybean
Soybean is an economically significant crop primarily valued for its seeds, which are rich in both high-quality protein and oil. The oil extracted from soybeans is widely used for culinary purposes and industrial applications, including the production of biodiesel. Its dual role as a major oilseed and a protein source makes it a cornerstone of global food and economic systems.

80. (D) Transgenic plant
A transgenic plant is an organism that has had a specific gene from another species inserted into its genome using genetic engineering techniques. These plants are created to possess beneficial traits such as resistance to pests, tolerance to herbicides, or enhanced nutritional content. This technology allows for precise modifications that are often impossible to achieve through traditional cross-breeding methods alone.

81. (A) Wheat
Wheat is one of the most important cereal crops globally, serving as a staple food for a large portion of the human population. It is a primary source of carbohydrates and provides essential energy in the form of flour for bread and other products. As a member of the grass family, its cultivation is central to global agriculture and food security.

82. (B) Protein
Pulses, such as lentils, chickpeas, and beans, are essential in economic botany because they are a primary source of vegetable protein for humans. They are particularly important in vegetarian diets. Additionally, pulses are valued for their ability to fix nitrogen in the soil, which enhances agricultural sustainability by improving soil health and reducing the need for chemical nitrogen fertilizers.

83. (C) Fibre
Cotton is a major industrial crop grown primarily for its natural fibres, which are used to produce textiles and clothing. The fibres are obtained from the protective case, or boll, that surrounds the seeds. Cotton is one of the most important non-food crops globally, supporting a massive textile industry and providing a livelihood for millions of farmers and workers.

84. (D) The evolution of the study of human-plant interactions over time.
Reviewing the history of ethnobotany is essential for understanding how the discipline has evolved from simple plant documentation to a sophisticated interdisciplinary science. It shows how past explorations and traditional knowledge have shaped our current understanding of plant uses and conservation. This historical perspective helps researchers appreciate the cultural foundations of botanical science and guides future studies in human-plant relationships.

85. (A) Ethnoveterinary medicine
Ethnoveterinary medicine is the study of traditional knowledge and practices used by indigenous cultures to maintain the health and treat the diseases of their livestock and pets. This field documents the use of specific plants, minerals, and traditional techniques for animal care. It is a vital area of research for developing sustainable and accessible veterinary treatments based on local resources.

86. (C) Statement I is true, but Statement II is false.
Documenting indigenous knowledge is a primary goal of ethnobotany because this wisdom is rapidly disappearing. Contrary to the second statement, this documentation has immense practical value in modern science, particularly in drug discovery and sustainable agriculture. Traditional knowledge often provides the foundational leads that scientists use to develop new medicines and more resilient farming systems for the modern world.

87. (B) Digitalis purpurea
Digitalis purpurea, the foxglove, is a well-known plant used in modern allopathic medicine to derive heart medications like digoxin. While transgenic plants are important in research, they are not typically categorized as traditional plants used in established major systems of medicine. Digitalis remains a classic example of a wild plant whose chemical properties were harnessed to create standardized, life-saving pharmaceutical drugs.

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human livelihoods and global economies. This field bridges the gap between basic plant science and the practical application of plants in fulfilling human needs and driving economic growth.

124. (B) Containing living cells capable of division.
For a substance to be used as an explant in tissue culture, it must contain living cells that are capable of division and differentiation. The success of micropropagation relies on the totipotency of these cells, which allows them to regenerate into a whole new plant when placed on a nutrient-rich medium. Dead or severely damaged tissues cannot initiate the necessary biological processes for successful culture.

125. (D) Microbial fermentation
Microbial fermentation is an industrial process that uses microorganisms like bacteria or fungi to create valuable products such as antibiotics, enzymes, and biofuels in controlled bioreactors. This technology allows for the mass production of these substances under optimized conditions of temperature, pH, and nutrition. It is a fundamental technique in biotechnology, providing essential products for medicine, food processing, and sustainable energy on a global scale.

126. (A) Produces its own insecticide.
Bt-crops are transgenic plants engineered by inserting genes from the bacterium Bacillus thuringiensis into the plant genome. These genes enable the plant to produce specific proteins that are toxic to certain insect pests, providing built-in protection against damage. This biotechnology reduces the need for external chemical pesticides, promoting more sustainable agricultural practices while effectively managing pest populations in diverse farming environments across the globe.

127. (C) Gram (Chickpea)
Gram, or chickpea, is a major pulse crop belonging to the family Fabaceae. It serves as a vital source of dietary protein and essential minerals for millions of people worldwide. In agricultural systems, gram is highly valued for its ability to fix atmospheric nitrogen, which improves soil fertility and reduces the need for chemical fertilizers in crop rotation cycles, supporting sustainable food production.

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128. (A) Q, R, S, P
The history of ethnobotany begins with early documentation by naturalists, followed by the formal coining of the term by John Harshberger in 1895. Later developments included the specialized study of ancient plant remains (archaeoethnobotany) and the use of modern phytochemical analysis to validate traditional claims. This chronological sequence shows the discipline's evolution from simple observation to a rigorous, multidisciplinary scientific field of study.

129. (A) Ethnotoxicology
Ethnotoxicology is the sub-discipline of ethnobotany that focuses on the traditional knowledge and use of poisonous plants by various cultures. This includes plants used for hunting, fishing, and as traditional punishments or in warfare. Researchers in this field study the chemical nature of these toxins and the cultural context of their application, providing insights into how humans have identified and utilized lethal botanical properties.

130. (A) Both A and R are true and R is the correct explanation of A.
Plant tissue culture must be performed in a sterile environment because the nutrient media used are also ideal for the growth of bacteria and fungi. These microorganisms grow much faster than plant cells and can quickly contaminate and kill the culture. Sterilization techniques like autoclaving and working in laminar air flow cabinets are essential to ensure the healthy growth and regeneration of plant tissues.

131. (D) Aromatic heartwood and essential oil.
The primary ethnobotanical importance of Santalum album, or sandalwood, lies in its aromatic heartwood and the precious essential oil extracted from it. Sandalwood has been used for centuries in religious ceremonies, traditional medicine, and cosmetics for its cooling and fragrant properties. Due to its slow growth and high value, the tree is heavily protected and is considered one of the most culturally and economically significant trees.

132. (B) It is based on the teachings of Greek physicians Hippocrates and Galen.
The Unani system of medicine is based on the traditional medical theories of the ancient Greek physicians Hippocrates and Galen. It was later expanded by Arab and Persian scholars, becoming a major medical system in the Islamic world and beyond. Unani medicine focuses on the balance of four humors in the body and utilizes various natural substances, primarily plants, to maintain health and treat disease.

133. (A) 1 and 3 only
Plant domestication by tribal people has significantly enriched global agricultural biodiversity, and the maintenance of sacred groves is a vital traditional conservation practice. However, a totem is a sacred emblem of a clan, not necessarily a forbidden food, although some taboos may apply. These concepts illustrate how cultural beliefs and traditional practices directly contribute to the preservation of plant species and the protection of natural habitats.

134. (D) Roots believed to impart strength and vitality.
Withania somnifera is called Ashwagandha because its roots have a distinct smell resembling that of a horse and because it is believed to impart the strength and vitality of a horse to those who consume it. In ethnobotany, this plant is valued as an adaptogen that helps the body cope with stress while promoting overall physical and mental health, longevity, and reproductive vigour.

135. (A) Gingerol
Gingerol is the primary bioactive compound found in the rhizome of Zingiber officinale (ginger), responsible for its characteristic pungent flavour and numerous medicinal properties. It has significant anti-inflammatory, antioxidant, and anti-nausea effects. Ethnobotanically, gingerol-rich preparations are used globally to treat digestive issues, pain, and motion sickness, making ginger a vital medicinal food and a cornerstone of traditional healing systems across many cultures.

136. (B) Strychnos nux-vomica
Strychnos nux-vomica is the botanical source of strychnine, a potent alkaloid that acts as a central nervous system stimulant. While it is highly toxic and historically used as a poison for hunting and pest control, it was also used in minute, carefully controlled doses in traditional medicine. Its study in ethnobotany highlights how different cultures have harnessed both the lethal and therapeutic potential of powerful plant toxins.

137. (C) Statement I is true, but Statement II is false.
The seeds of Eugenia jambolana (Jamun) are traditionally used in many cultures to help manage blood sugar levels in diabetic patients. Contrary to the second statement, the fruits are not poisonous; they are edible, highly nutritious, and widely consumed for their sweet and tangy flavour. Both the fruit and the seeds play important roles in traditional diets and medicinal practices for maintaining health and managing metabolic disorders.

138. (D) Mentha arvensis
Menthol is the primary active ingredient obtained from the essential oil of Mentha arvensis, or wild mint. It is highly valued for its cooling sensation and local anaesthetic properties, making it a key component in medicinal balms, cough drops, and confectionary. Ethnobotanically, mint is used for its refreshing aroma and its ability to relieve headaches, respiratory congestion, and digestive discomfort across many global cultures.

139. (A) Ricinus communis
Ricinus communis, the castor oil plant, is frequently recommended in traditional medicine for treating rheumatism and joint pain. The oil extracted from its seeds is applied externally as a poultice or massaged into the skin for its anti-inflammatory and analgesic effects. This traditional use is based on the oil's ability to penetrate tissues and reduce the pain and swelling associated with chronic inflammatory conditions.

140. (B) Azadirachta indica
A traditional blood purifier and treatment for skin infections would most likely include parts of Azadirachta indica, or Neem. Neem is renowned for its potent antimicrobial, antifungal, and detoxifying properties. In many cultures, consuming its bitter leaves or using its oil is a primary method for cleansing the body of impurities and treating various skin conditions, reflecting its status as a versatile and powerful medicinal tree.

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141. (B) Astringent and anti-inflammatory
Traditional remedies for piles (hemorrhoids) typically use plants with astringent and anti-inflammatory properties to reduce swelling and stop bleeding. These plants help shrink the swollen veins and provide relief from pain and itching. This traditional approach focuses on localized treatment and systemic management of inflammation, using botanical extracts that have been proven effective over generations for treating this common and uncomfortable condition.

142. (A) Somatic embryogenesis
Somatic embryogenesis is the process in plant tissue culture where embryos are developed from vegetative (somatic) cells rather than through the fusion of gametes. These somatic embryos can regenerate into complete plantlets that are genetically identical to the parent. This technique is a powerful tool for mass propagation and is fundamental to many biotechnological applications, including the production of artificial seeds and the regeneration of transgenic plants.

143. (C) Production of fossil fuels.
Plant tissue culture is widely used for clonal propagation, conserving endangered species, and producing secondary metabolites like drugs and dyes. However, it is not used for the production of fossil fuels. Fossil fuels are formed over millions of years from decomposing organic matter under high pressure and temperature in the earth's crust. While plants are the source of biofuels, tissue culture is not involved in fossil fuel production.

144. (D) Withania somnifera
Withania somnifera, or Ashwagandha, is a highly important drug-yielding plant that is found both growing wild and being widely cultivated for its medicinal roots. Its use as a powerful adaptogen and tonic makes it a high-demand species in traditional medicine and the modern herbal industry. Its successful cultivation ensures a steady supply of this valuable botanical resource for global health and wellness products.

145. (C) Organogenesis forms organs sequentially, while somatic embryogenesis forms a bipolar structure resembling a zygotic embryo.
In organogenesis, plant organs like shoots and roots develop one after another, often requiring different media. Somatic embryogenesis, however, involves the formation of a bipolar structure that contains both a shoot and a root pole simultaneously, much like a regular seed embryo. This structural difference is fundamental, as somatic embryos can directly germinate into complete plants more efficiently than organs produced through sequential organogenesis.

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146. (A) P-4, Q-1, R-2, S-3
Ethno-gynaecology studies plants for women's health, and ethno-linguistics examines plant names in various cultures. Archaeoethnobotany analyzes ancient plant remains, and ethnopharmacology investigates the biological effects of traditional remedies. Each sub-field represents a unique approach to studying human-plant interactions, combining different academic disciplines like medicine, linguistics, archaeology, and chemistry to provide a comprehensive understanding of how plants have shaped human history and culture.

147. (B) Cultural/religious belief
Protecting a grove of trees because it is believed to be the home of a deity is a classic example of conservation driven by cultural and religious beliefs. These sacred groves act as protected areas where biodiversity can flourish undisturbed. This traditional method of conservation is often highly effective because it is rooted in deep-seated spiritual values and social norms, providing long-term protection for vital local ecosystems.

148. (D) Samuel Hahnemann
The Homeopathic system of medicine was developed by the German physician Samuel Hahnemann in the late 18th century. It is based on the principle of "like cures like," using extremely diluted substances to stimulate the body's natural healing response. Hahnemann's revolutionary approach emphasized the importance of individualizing treatment and minimizing the side effects of medications, creating a unique and lasting system of alternative medicine.

controlled environment. However, wooden furniture is manufactured through the mechanical processing of timber from trees and does not involve any microbial fermentation. Understanding this distinction is fundamental to identifying different industrial applications of biological and botanical resources.

98. (B) Somatic hybridization
Somatic hybridization is the most appropriate technique for creating hybrids between sexually incompatible species. By fusing the protoplasts of two different plants in a laboratory, scientists can combine their genetic material regardless of natural reproductive barriers. This allows for the development of new varieties, like a hybrid potato, that possess desirable traits from both parent species, which would be impossible through traditional breeding.

99. (C) Sterilization
An autoclave is a vital piece of equipment in plant tissue culture labs used for sterilization. It uses high-pressure steam at high temperatures to kill all microorganisms, including spores, on laboratory equipment and in nutrient media. Ensuring a completely sterile environment is essential to prevent contamination, which can otherwise quickly destroy sensitive plant tissue cultures in the laboratory.

100. (B) P-4, Q-1, R-2, S-3
Accurate botanical identification connects common plant names with their scientific designations. Tulsi is Ocimum sanctum, while Ashwagandha is Withania somnifera. Sarpagandha refers to Rauvolfia serpentina, and Kalmegh is Andrographis paniculata. Correctly matching these names is essential for scientific communication and for understanding the specific medicinal properties and cultural significance associated with each of these important plant species.

101. (D) Phytodegradation
Phytodegradation is a specific mechanism of phytoremediation where plants absorb environmental contaminants and break them down into less harmful substances through internal metabolic processes. This process occurs within the plant's tissues, effectively neutralizing organic pollutants. It is a sustainable way to treat contaminated soil and water, utilizing the natural enzymatic capabilities of plants to clean the environment without removing the biomass.

102. (A) Ethnotaxonomy
Ethnotaxonomy is the study of how different cultures perceive, name, and classify the plants in their local environment. It explores the logic behind folk classification systems, which are often based on the practical use or visible characteristics of the plants. Understanding these systems is crucial for documenting indigenous knowledge and recognizing the sophisticated biological understanding held by traditional societies.

103. (D) Statement I is false, but Statement II is true.
Modern allopathic medicine does not reject plant-derived compounds; in fact, many essential drugs originated from plants. For instance, morphine was isolated from the opium poppy and atropine from belladonna. While allopathy uses many synthetic drugs, it continues to rely on plant chemistry for both direct use and as templates for developing new pharmaceutical treatments for various medical conditions.

104. (B) Taboo
A social rule that forbids the cutting of a specific tree is a clear example of a plant taboo. Such prohibitions are often based on religious beliefs or the perceived sacredness of the tree. These cultural restrictions serve as effective traditional conservation tools, ensuring that important species or specific individual trees are protected from human interference and overexploitation within a community.

105. (C) Ethnomusicology
Ethnomusicology, in an ethnobotanical context, is the study of how plants are used to create traditional musical instruments. This includes using hollow bamboo for flutes, gourds for resonators, and specific hardwoods for drums or stringed instruments. This field explores the intersection of botany and culture, documenting how the physical properties of plants are utilized to produce sound and express artistic heritage.

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157. (A) Rauvolfia serpentina
Rauvolfia serpentina is commonly known as Sarpagandha because its roots were traditionally used as an antidote for snake bites due to their snake-like appearance. Beyond this, the plant is famous for its powerful tranquilizing and blood-pressure-lowering effects, often being used to treat mental disorders like insanity. Its historical importance is reflected in its widespread use across diverse traditional medical systems for managing various severe systemic and neurological conditions.

158. (A) 2 only
Anther culture is used to produce haploid plants, not diploid ones, and somatic hybridization involves the fusion of protoplasts, not gametes. However, the requirement for a sterile medium containing specific nutrients and hormones is a fundamental truth for all tissue culture techniques. Ensuring these precise conditions is essential for the growth and regeneration of plant tissues in a laboratory setting, making the second statement the only correct one.

159. (D) Leaves
The red dye known as henna is primarily extracted from the leaves of the Lawsonia inermis plant. The leaves are dried and powdered, and when mixed with water, they release a pigment called lawsone that stains the skin and hair. This natural dye has been used for thousands of years in ethnocosmetics for body art and hair colouring, reflecting its long-standing cultural and aesthetic importance.

160. (A) Pulse
A protein-rich product derived from a non-timber forest plant that functions as a dietary staple would be classified as a pulse. Pulses are the edible seeds of leguminous plants and are vital for human nutrition, especially as a source of plant-based protein. Many communities rely on both cultivated and wild-gathered pulses to fulfill their protein requirements, highlighting the economic and nutritional value of these botanical resources.

161. (C) Eyes
Ethno-ophthalmology is the study of traditional plant-based remedies used by indigenous cultures to treat diseases and conditions of the eyes. This specialized branch of ethnobotany documents the use of various herbal washes, pastes, and decoctions believed to heal infections or improve vision. Research in this field preserves unique cultural medical knowledge and identifies potential natural treatments for modern ocular health challenges using traditionally recognized botanical agents.

162. (B) The protection and conservation of the totem species.
Totemism often leads to the protection of specific plant or animal species because the community views the totem as a sacred ancestor or emblem. Because harming the totem is strictly forbidden by cultural and religious norms, the species is effectively shielded from overexploitation. This traditional belief system serves as a powerful and enduring mechanism for biodiversity conservation, ensuring that certain species are maintained within the local environment for generations.

163. (C) Ethnoecology - Study of plant-based poisons
Ethnoecology is the study of traditional perceptions and management of ecosystems, not the study of plant poisons, which is known as ethnotoxicology. The other pairings correctly identify ethnomedicine with traditional medicine, ethnotaxonomy with plant classification, and ethnomusicology with plants in music. Correctly defining these sub-disciplines is essential for understanding the diverse ways in which humans interact with and gain knowledge from the botanical world.

164. (D) Purgative
The fruit pulp of Cassia fistula (Indian Laburnum) is traditionally valued for its gentle yet effective purgative properties. It is used as a natural laxative to treat constipation and clear the digestive system. This use is well-documented in many traditional medicine systems, where the pulp is often prepared as a paste or infusion, providing a reliable botanical solution for maintaining healthy bowel function.

165. (A) The dried, unopened flower bud
The spice known as clove consists of the dried, unopened flower buds of the Eugenia aromatica (or Syzygium aromaticum) tree. These buds are harvested just before they open and are

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231. (B) Ethnonarcotics
Ethnonarcotics is the specialized field of ethnobotany that focuses on the traditional use of psychoactive plants in rituals and cultural practices. These plants are used to induce altered states of consciousness, which are often viewed as a way to communicate with spirits or the divine. The study explores the cultural significance, preparation methods, and spiritual beliefs surrounding these powerful botanical agents, providing insight into the complex relationship between humans, sacred plants, and the spiritual world.

232. (A) Both Statement I and Statement II are true.
The historical review of ethnobotany shows a clear shift from simple documentation to a modern interdisciplinary science that includes phytochemical and pharmacological validation. Modern research often focuses on testing the traditional claims made by indigenous communities using rigorous scientific methods. Both statements are accurate, as they reflect the evolution of the discipline and its current emphasis on integrating traditional wisdom with modern scientific analysis to discover new medicines and understand plant properties more deeply.

233. (C) Offer clues about the cultural and medicinal importance of plants.
Folklore and folktales are significant in ethnobotany because they provide important clues about how plants have been perceived and utilized by different cultures over generations. These stories often highlight a plant's medicinal value, its role in traditional rituals, or its ecological importance. While not scientifically formatted, these narratives serve as a vital starting point for researchers to identify plants with unique properties that can then be investigated through more formal botanical and chemical studies.

234. (D) Strychnos nux-vomica
Strychnos nux-vomica is the source of the potent alkaloid strychnine, which acts as a powerful stimulant of the central nervous system. In higher doses, it is a deadly neurotoxin that causes severe muscle spasms and respiratory failure. Its ethnobotanical history includes its use in both traditional medicine and as a poison for hunting. The plant's significance lies in its extreme physiological effects, illustrating how humans have identified and managed the most powerful and dangerous botanical substances in nature.

235. (A) Diabetes mellitus
The seeds of Eugenia jambolana, or Jamun, are traditionally used in the management of diabetes mellitus across many cultures. They contain bioactive compounds that help regulate blood sugar levels by inhibiting the breakdown of starch into sugar and improving insulin sensitivity. This use is a prime example of an ethnobotanical remedy for a chronic metabolic disorder, and Jamun seeds remain a popular natural supplement for managing diabetes in traditional and modern herbal healthcare systems today.

236. (A) Both A and R are true and R is the correct explanation of A.
Meristem culture is a reliable method for obtaining virus-free plants because viruses typically travel through a plant's vascular tissues, which are not yet fully developed in the apical meristem. Additionally, the rapid division of meristematic cells often outpaces the replication of the virus, leaving the very tip of the shoot healthy. By culturing this small, virus-free segment, scientists can regenerate completely healthy clones of valuable plant varieties that were previously infected with harmful viral diseases.

237. (B) 2 and 3 only
Somatic hybridization effectively creates hybrids between sexually incompatible species, and anther culture is used to rapidly produce homozygous diploid lines after chromosome doubling. However, cryopreservation is used for long-term storage at ultra-low temperatures, not short-term storage at 4°C. Therefore, the second and third statements are correct, as they accurately describe important applications of tissue culture in plant breeding and genetic resource management, while the first statement incorrectly defines a key preservation technique.

238. (B) Oilseed crop
In economic botany, soybean (Glycine max) is classified as an oilseed crop because its seeds are a primary global source of vegetable oil. The oil extracted from soybeans is used extensively for cooking, food processing, and

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This biotechnology helps protect crop yields and improves farming efficiency by providing a targeted way to manage unwanted vegetation in the field.

174. (A) Cicer arietinum
Cicer arietinum, commonly known as chickpea or gram, is a classic example of a pulse crop. Pulses are leguminous plants valued for their edible, protein-rich seeds. They are a vital part of global food security, providing essential nutrition and improving soil health through nitrogen fixation. In many cultures, chickpeas are a staple food, used in a wide variety of traditional dishes for their high nutritional value and versatility.

175. (B) Ethnopaediatrics
Ethnopaediatrics is the specialized sub-discipline of ethnobotany that focuses on traditional knowledge regarding the treatment of children's diseases using plants. This field documents how various cultures have developed specific botanical remedies and dosage forms suitable for infants and young children. Understanding these practices is important for preserving traditional wisdom and identifying safe, effective natural treatments for common pediatric ailments based on long-standing cultural medical experience.

176. (B) A patch of forest protected on the basis of religious beliefs.
A sacred grove is a fragment of forest or natural vegetation that is protected by local communities due to religious or spiritual beliefs. These areas are often dedicated to a deity or ancestral spirits, and cutting trees or harming wildlife within them is strictly forbidden. Sacred groves serve as vital refuges for biodiversity, acting as natural gene banks and maintaining local ecosystem services in an otherwise modified landscape.

177. (A) Simile
The phrase "a face as pale as a lily" is an example of a simile, a figure of speech that compares two things using "as" or "like." In this case, the lily's well-known white colour is used to describe human skin. Plant-based similes reflect the close observation of nature by human cultures and illustrate how botanical characteristics are woven into language and literature to convey vivid descriptive meanings.

178. (A) 3 only
Cannabis sativa is indeed a source of both industrial fibre and psychoactive compounds, making the third statement correct. However, Aconitum napellus is highly toxic, not benign, and Atropa belladonna is a source of atropine, not caffeine. This emphasizes the importance of accurate botanical and chemical knowledge in ethnobotany, as the properties of plants can range from being useful industrial materials to dangerous poisons or powerful medicinal agents.

179. (C) The amoeba Entamoeba histolytica.
The bark of Holarrhena antidysenterica contains alkaloids such as conessine that are specifically effective against Entamoeba histolytica, the parasite responsible for amoebic dysentery. This plant is a primary traditional remedy for severe gastrointestinal infections because its chemical constituents can effectively kill or inhibit these harmful microorganisms. Its use demonstrates a targeted and effective botanical approach to treating a common and potentially dangerous parasitic infection found in many tropical regions.

180. (A) Cope with physical and mental stress.
As an adaptogen, Withania somnifera (Ashwagandha) helps the body maintain balance and resist the negative effects of various stressors. It works by supporting the adrenal glands and modulating the body's stress response. This property makes it highly valued in traditional medicine for improving resilience, reducing anxiety, and enhancing overall vitality, allowing individuals to better handle the physical and mental challenges of daily life and promote long-term well-being.

181. (C) Statement I is true, but Statement II is false.
The rhizome of Zingiber officinale (ginger) is a well-documented traditional remedy for nausea and motion sickness, effectively used for centuries. However, it is not a major industrial source of ethanol; crops like sugarcane and corn are primarily used for that purpose. Therefore, while ginger's medicinal importance is accurately stated, its role as a primary biofuel source is incorrect, highlighting its specific value as a medicinal spice rather than an industrial fuel.

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and effective natural alternatives for reproductive care in modern medicine.

199. (A) Make a yellow or orange dye.
The vibrant orange-red flowers of Butea monosperma are traditionally used to make a natural dye. When soaked or boiled in water, they release a pigment that produces a bright yellow or orange colour, which is famously used during the Holi festival. This ethnobotanical use reflects the plant's cultural significance and its value as a natural, sustainable source of pigments for traditional celebrations and textile colouring.

200. (D) Statement I is false, but Statement II is true.
Anther culture is specifically used to produce haploid plants, which have only one set of chromosomes, not diploid ones. On the other hand, meristem culture is an established and highly effective method for producing virus-free plant clones because the meristematic tissue is often free from viral infection. Correctly identifying these specific tissue culture techniques is essential for their proper application in plant breeding, conservation, and the production of healthy planting material.

201. (D) As a primary source of edible fruit for humans.
Butea monosperma, known as the Flame of the Forest, is valued for its dye-yielding flowers, its use as cattle fodder, and its role as a host for the lac insect. However, its fruits are not a primary food source for humans. This plant's importance lies in its ecological and industrial roles rather than as a staple food crop, demonstrating the diverse non-food uses that plants provide to traditional and modern societies.

202. (B) Sterilization of the nutrient medium and fermenter.
A critical step in industrial fermentation is the sterilization of both the fermenter and the nutrient medium to prevent the growth of unwanted microorganisms. Contamination can lead to lower yields or the production of harmful toxins, ruining the entire batch. Ensuring a completely sterile environment allows the desired microorganism to grow and produce the target product efficiently, which is essential for the reliable mass production of pharmaceuticals, food additives, and biofuels.

203. (C) Soybean
Soybean is a major Kharif (summer-sown) crop that is highly valued for its seeds, which are rich in both high-quality oil and protein. It is one of the most important oilseeds globally, providing a significant portion of the world's vegetable oil and animal feed. Its dual nutritional profile and industrial versatility make it a cornerstone of modern agriculture, supporting food security and diverse economic sectors through its varied applications.

204. (A) Q, P, S, R
Somatic hybridization begins with isolating protoplasts from parent cells, followed by their fusion in a laboratory. Next, the resulting hybrid cells must be carefully selected from non-fused cells. Finally, these selected hybrid cells are induced to regenerate into a whole, complete plant through tissue culture techniques. This systematic sequence is essential for successfully creating new plant varieties with combined traits from species that cannot be crossed using traditional sexual methods.

205. (D) Archaeoethnobotany
Archaeoethnobotany is the interdisciplinary study of plant remains found at archaeological sites to understand how ancient people used botanical resources. By identifying seeds, charcoal, and pollen from ancient settlements, researchers can reconstruct past diets, agricultural practices, and environmental conditions. This field provides critical evidence of the history of plant domestication and the long-term evolution of the relationship between humans and their local plant world across different civilizations.

206. (A) A specific clan being forbidden from eating the fruit of a particular tree.
A plant taboo is a cultural or religious prohibition that restricts the use or consumption of a specific plant species. An example is when a clan is forbidden from eating a particular fruit, often because the plant is considered sacred or linked to a spiritual belief. These taboos play an important role in traditional conservation by preventing overexploitation and ensuring the long-term survival of important botanical resources within the community's environment.

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bile, and black bile) and the need to keep them in balance to maintain health. Unani medicine uses a holistic approach, incorporating diet, lifestyle, and primarily plant-based medications to treat various ailments and promote overall physical well-being.

191. (B) P-2, Q-3, R-4, S-1
A totem is a sacred clan emblem, while a taboo is a social prohibition. A simile is a comparison using "like" or "as," and folklore consists of traditional stories passed down through generations. These terms define the various cultural and linguistic ways that human societies interact with and describe the natural world. Understanding these concepts is essential for analyzing the complex social and spiritual relationships between people and their botanical environment.

192. (A) The latex from the incised unripe capsule
Opium alkaloids are obtained from the milky latex that oozes out when the surface of the unripe seed capsule of Papaver somniferum is scratched or incised. This latex is collected and dried to produce raw opium, which contains morphine, codeine, and other important medicinal compounds. This traditional method of harvesting is still used today and remains the primary source for these essential pain-relieving substances in pharmaceutical production.

193. (C) Fruits
Triphala is a classic Ayurvedic herbal formulation made from a combination of the dried fruits of three specific medicinal trees: Haritaki, Bibhitaki, and Amla. The use of these three fruits together is believed to create a balanced tonic that supports digestive health, detoxifies the body, and promotes overall longevity. Each fruit provides unique therapeutic benefits, and their combination is one of the most widely used and respected remedies in traditional Indian medicine.

194. (C) Micropropagation
Micropropagation is the most suitable technique for rapidly producing a large number of genetically identical clones of a superior parent plant, such as a high-yielding banana. This tissue culture method allows for the mass multiplication of disease-free plantlets in a controlled laboratory environment. It is an essential tool for modern agriculture and horticulture, ensuring that farmers have access to uniform, high-quality planting material for large-scale crop production and variety improvement.

195. (C) A is true but R is false.
Soybean is an economically important crop, but it is primarily valued for its high protein and oil content, not for starch. Unlike cereals like wheat, which are starch-heavy, soybeans are a critical source of vegetable protein and industrial oil. This distinction is vital in economic botany, as it determines how the crop is utilized in food processing, animal feed, and the manufacturing of various commercial products like biodiesel.

196. (B) Enzymes like cellulase and pectinase
To obtain protoplasts for somatic hybridization, the rigid cell walls of plant cells must be removed. This is achieved using enzymes like cellulase and pectinase, which break down the cellulose and pectin components of the cell wall. Once the walls are removed, the remaining naked cells (protoplasts) can be fused together in a laboratory to create hybrids. This enzymatic process is a fundamental step in many advanced plant biotechnology procedures.

197. (C) Withania somnifera
Withania somnifera, or Ashwagandha, is a major drug-yielding plant that is found growing wild in arid regions and is also widely cultivated to meet commercial demand. Its medicinal roots are used in a vast range of health products. The dual availability from both wild and cultivated sources highlights its importance and the need for sustainable management to ensure that this valuable botanical resource remains available for traditional and modern medical use.

198. (D) Plants related to female reproductive health, childbirth, and contraception.
Ethno-gynaecology is a specialized branch of ethnobotany that focuses on the traditional use of plants for women's reproductive health. This includes remedies for menstrual issues, support during pregnancy and childbirth, and traditional methods of contraception. Documenting this knowledge is vital for understanding how different cultures have managed women's health for generations and for identifying potentially safe

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approach offers a cost-effective and scalable way to produce essential medicines, demonstrating how the genetic modification of plants can provide innovative solutions for modern healthcare challenges by creating biological systems that produce standardized therapeutic compounds.

216. (C) Anthropology
Ethnobotany is an interdisciplinary science that combines the study of plants (botany) with the study of human cultures and societies (anthropology). It explores how different groups of people interact with and perceive their local botanical environment. By combining these two fields, researchers can gain a comprehensive understanding of how traditional plant knowledge is shaped by cultural values, history, and social structures, providing a unique perspective on the human-plant relationship across the globe.

217. (D) Ethnolinguistics
A researcher studying local plant names and their meanings within a tribal dialect is working in the field of ethnolinguistics. This area of ethnobotany examines how language reflects a culture's knowledge and classification of plants. Documenting these terms provides deep insights into the historical and cultural significance of various species to the community. It also helps preserve linguistic diversity, which is often closely linked to the preservation of traditional ecological and medicinal knowledge.

218. (C) Statement I is true, but Statement II is false.
The Ayurvedic system of medicine is indeed an indigenous Indian system with ancient roots in the Vedas. However, the Unani system of medicine did not originate in China; it developed from ancient Greek medical theories and was expanded by Arab and Persian scholars. Understanding the correct historical origins of these major medical systems is essential for appreciating their unique philosophies and the different cultural paths that led to their development and global spread.

219. (C) Domestication
Domestication is the intentional process where humans select and breed wild plants with desirable traits to create crops that are better suited for agriculture. This long-term selection leads to genetic and physical changes that distinguish the domesticated crop from its wild relatives. Domestication is the foundation of human civilization, as it allowed for the development of stable food supplies and the transition from nomadic lifestyles to sedentary, agricultural-based societies across the world.

220. (B) "Her skin was as smooth as a lotus petal."
This phrase is a perfect example of a plant simile, as it uses a comparison with the word "as" to highlight a characteristic of the plant applied to a human. Comparing skin to a lotus petal draws on the well-known smoothness and beauty of the flower to create a vivid description. Such linguistic expressions show how plants serve as important cultural and aesthetic references in human language and communication across different societies.

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221. (C) P-3, Q-4, R-1, S-2
Emblica officinalis is commonly known as Amla, while Aloe vera provides the well-known aloe gel. Lawsonia inermis is the source of henna dye, and Cannabis sativa is used to produce hemp and marijuana. Correctly matching these botanical names with their common names and products is essential for scientific communication and for understanding the diverse ways in which these plants are utilized in medicine, industry, and traditional cultural practices globally.

222. (D) Tetrahydrocannabinol (THC)
Tetrahydrocannabinol, or THC, is the primary psychoactive compound found in the resin of the Cannabis sativa plant. It is responsible for the altered states of consciousness associated with the use of marijuana in traditional rituals and recreational contexts. Ethnobotanical study of Cannabis involves understanding how different cultures have used the plant for its psychoactive, medicinal, and industrial properties, and how the concentration of THC varies across different varieties and preparation methods.

223. (A) Astringent
The "gum-kino" obtained from the bark of Pterocarpus marsupium is traditionally valued for its powerful astringent properties. Astringents cause the contraction of body tissues, which is useful for stopping bleeding and treating diarrhea or wounds. This medicinal gum is a significant ethnobotanical product,

207. (B) Modern or Western medicine
The Allopathic system of medicine is commonly known as modern or Western medicine. It is based on a scientific approach to diagnosing and treating diseases using standardized drugs, surgery, and other evidence-based interventions. While it often incorporates compounds originally derived from plants, allopathy is characterized by its focus on biological mechanisms and the rigorous testing of treatments to ensure their safety and efficacy in clinical practice worldwide.

208. (B) Spice and antiseptic oil.
Eugenia aromatica, the clove tree, is ethnobotanically significant as the source of a popular culinary spice and a powerful antiseptic oil. Cloves are used worldwide for their strong aromatic flavour, while clove oil, containing eugenol, is a common traditional remedy for toothaches and infections. Its dual role in both the kitchen and the medicine cabinet highlights its importance as a versatile botanical resource for health and flavour.

209. (B) 2 and 3 only
Terminalia bellerica is a key component of the Triphala formulation, and Terminalia chebula is highly respected as a versatile medicine. However, Terminalia arjuna is primarily used as a cardiotonic for heart health, not for respiratory ailments. Correctly identifying the specific medicinal roles of these Terminalia species is crucial for their proper application in traditional medicine and for understanding their unique therapeutic benefits for different systems of the human body.

210. (D) Ricin
The seeds of Ricinus communis are extremely toxic because they contain a potent protein called ricin. Even a small amount of ricin can be fatal if ingested, as it inhibits protein synthesis in cells. However, when the seeds are processed to extract castor oil, the ricin is removed or inactivated, making the oil safe for use as a laxative. This stark contrast highlights the importance of proper processing in traditional and industrial medicine.

211. (C) A is true but R is false.
Ocimum sanctum (Tulsi) is a revered plant in many cultures for its significant medicinal properties, especially for treating respiratory issues and stress. However, it is not cultivated for timber, as it is a small herbaceous plant rather than a large woody tree. Its value lies in its leaves and aromatic oils, making it a cornerstone of traditional healthcare and household remedies rather than a source of construction material.

212. (A) Azadirachta indica
For a severe skin infection like scabies, a traditional healer would most likely recommend Azadirachta indica, or Neem. Neem contains powerful antimicrobial and antiparasitic compounds that are highly effective at killing the mites that cause scabies and preventing secondary infections. Its widespread use as a natural treatment for various skin conditions is based on its proven efficacy and its long history of reliable application in traditional dermatological care.

213. (B) Callus
In plant tissue culture, a callus is a mass of undifferentiated, actively dividing cells that forms when an explant is placed on a nutrient medium. This mass of tissue can be induced to regenerate into new plant organs or embryos by changing the hormone balance in the medium. The formation of a callus is often a necessary intermediate step in the micropropagation and genetic modification of plants in a laboratory setting.

214. (B) Long-term conservation of genetic resources in a viable state.
The primary goal of cryopreservation is the long-term conservation of plant germplasm, such as seeds, embryos, or tissue samples, in a viable state. By storing these materials at the ultra-low temperature of liquid nitrogen, all biological processes are halted, preventing genetic degradation. This technique is essential for protecting the genetic diversity of crops and endangered wild species, ensuring that their unique traits are preserved for future agricultural and scientific needs.

215. (A) Transgenic plant used for molecular farming
A transgenic plant engineered to produce human proteins like insulin is an example of molecular farming. This biotechnology uses the plant's cellular machinery as a biological factory to manufacture valuable pharmaceuticals. This

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182. (D) Terminalia arjuna bark
Butea monosperma seeds, Neem, and castor oil are all traditionally used for their anthelmintic properties to expel parasitic worms. However, Terminalia arjuna bark is primarily used as a cardiotonic for heart health and does not have a documented traditional use as an anthelmintic. This shows that traditional medicine assigns very specific roles to different plants based on their observed effects, ensuring targeted treatment for various health conditions.

183. (B) Provide a sterile working area.
Laminar air flow cabinets are essential in plant tissue culture because they provide a sterile working environment by filtering air through high-efficiency particulate air (HEPA) filters. This constant flow of clean air prevents dust and microorganisms from landing on the cultures or laboratory equipment during the transfer of plant tissues. Maintaining this sterility is critical for the successful growth and development of sensitive plant tissues in a controlled laboratory setting.

184. (C) Somatic hybrid or cybrid
The fusion of two protoplasts from different species results in a somatic hybrid, which contains the nuclear and cytoplasmic material from both parents. If the nucleus of one parent is lost or inactivated, the resulting cell is a cybrid (cytoplasmic hybrid). This technique allows for the creation of unique genetic combinations that are impossible through sexual reproduction, providing a powerful tool for transferring desirable traits and studying genetic interactions in plants.

185. (D) Wheat
Wheat is a major cereal crop and a global staple food, primarily valued as a source of carbohydrates for human energy. It is grown extensively in many parts of the world and is the foundation for a wide range of essential food products like bread and pasta. As a cereal, its economic and nutritional importance is unparalleled, making its cultivation central to the livelihoods of farmers and global food security.

186. (A) Phytoremediation
Phytoremediation is the broad term for using plants to clean up environmental contaminants in soil, water, and air. This include processes like absorbing heavy metals, degrading organic pollutants, or stabilizing contaminated sites to prevent the spread of toxins. It is a sustainable, plant-based technology that offers an eco-friendly alternative to traditional mechanical and chemical remediation methods, helping to restore polluted ecosystems and protect public health through natural biological processes.

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187. (B) Production of synthetic fertilizers.
Plant tissue culture is used for germplasm conservation, micropropagation, and the production of medicinal compounds (secondary metabolites). However, it is not involved in the production of synthetic fertilizers, which are manufactured through chemical industrial processes. Tissue culture focuses on the biological growth and manipulation of plant cells and tissues in a laboratory, rather than the large-scale chemical synthesis of agricultural nutrients used to enhance crop yields.

188. (B) Fibre-yielding plant
In economic botany, cotton is categorized as a fibre-yielding plant because its primary value lies in the natural cellulose fibres produced by its seeds. These fibres are harvested and processed into yarn and fabric, making cotton the most important natural fibre in the global textile industry. Its cultivation is driven by the demand for clothing and other textile products, highlighting its critical role as an industrial, non-food crop.

189. (A) Ethnolinguistics
Ethnolinguistics is the study of how language and culture are interconnected, specifically focusing on the specialized vocabulary a society uses to name and describe its local plants. This field explores the origins of plant names and how they reflect a community's understanding of its botanical environment. Documenting these terms is vital for preserving traditional knowledge, as the loss of local languages often means the disappearance of deep-seated ecological and medicinal wisdom.

190. (C) Unani
The Unani system of medicine originated in ancient Greece and was further developed by Arab and Persian physicians. It is based on the theory of the four humors (blood, phlegm, yellow

demonstrating the targeted use of specific plant exudates in traditional healing to address various health issues through their unique chemical and physical effects on human tissues and physiological processes.

224. (C) Stimulating pigment upon UV exposure.
Traditional medicine uses photosensitizing compounds from plants like Psoralea corylifolia to treat leucoderma by stimulating the production of skin pigment (melanin) when exposed to ultraviolet light. These compounds increase the skin's sensitivity to light in the affected white patches, helping to restore normal colour. This sophisticated traditional method illustrates how botanical knowledge is used to interact with environmental factors like sunlight to provide targeted therapeutic treatments for complex skin disorders across various cultures.

225. (A) Azadirachta indica
Azadirachta indica, or Neem, is a well-known traditional antipyretic used to reduce fever. Its leaves and bark contain bitter compounds that have been used for generations in various folk medicine systems to manage fevers associated with infections and other ailments. This use of Neem highlights its status as a versatile and accessible medicinal tree, providing a natural remedy for one of the most common symptoms of illness in both humans and animals across many tropical regions.

226. (A) To mix the contents and ensure uniform distribution of cells, nutrients, and oxygen.
The impeller is a rotating component in an industrial fermenter that is essential for mixing the liquid medium. Its primary role is to ensure that microorganisms, nutrients, and dissolved oxygen are evenly distributed throughout the vessel, preventing the formation of stagnant zones. This uniform environment is critical for the efficient growth of the culture and the consistent production of high-quality biological products like antibiotics, enzymes, and biofuels on an industrial scale.

227. (B) Microspores (pollen)
Anther culture is a tissue culture technique that exploits the totipotency of microspores, which are the immature pollen grains found within the anther. By placing these haploid cells on a specific nutrient medium, they can be induced to develop into whole haploid plants. This technique is highly valuable in plant breeding and genetics because it allows for the rapid creation of genetically uniform lines, significantly speeding up the process of developing new and improved crop varieties.

228. (C) Totipotency
The development of an entire, functional plant from a single, non-reproductive cell is the definitive demonstration of totipotency. This inherent biological potential is found in most living plant cells, allowing them to regenerate and differentiate into any other cell type when given the right environmental and hormonal cues. Totipotency is the fundamental principle that makes plant tissue culture, cloning, and genetic engineering possible, providing the basis for modern plant biotechnology and rapid micropropagation of superior varieties.

229. (D) Gossypium species
Gossypium species, commonly known as cotton, are the most important fibre-yielding plants in global economy. The natural cellulose fibres harvested from their seeds are used to produce a vast range of textile and industrial products. Cotton's role as a major non-food crop supports a massive global industry and provides a primary livelihood for millions of people. Its economic importance is driven by the universal demand for natural, breathable fabrics for clothing and other essential household items.

230. (A) Phytoextraction
Phytoextraction is a mechanism of phytoremediation where plants absorb environmental contaminants, such as heavy metals, from the soil through their roots and transport them to their harvestable shoots and leaves. The contaminants are then stored in these above-ground parts, which can be harvested and removed, effectively cleaning the soil. This process utilizes the natural ability of certain "hyperaccumulator" plants to concentrate high levels of toxins within their tissues without being harmed, providing a sustainable cleanup solution.

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dried until they turn dark brown. Cloves are highly valued for their strong aromatic flavour and their medicinal use as a local anaesthetic and antiseptic, particularly for dental pain and respiratory issues across many global cultures.

166. (B) Q, S, P, R
The relationship between humans and plants began in hunter-gatherer societies where people used plants for basic needs like food and shelter. This was followed by the establishment of agriculture through domestication. Much later, ethnobotany emerged as a formal academic discipline to study these ancient and modern interactions. This chronological sequence reflects the evolution of human society and the eventual scientific formalization of traditional botanical knowledge.

167. (D) Statement I is false, but Statement II is true.
Jatropha curcas seeds are not a safe source of edible protein because they contain toxic compounds that are harmful if consumed. However, these seeds are rich in non-edible oil that can be efficiently converted into biodiesel. This makes Jatropha a valuable industrial plant for sustainable energy production rather than a food crop, clearly distinguishing its economic role from that of traditional edible oilseeds and protein sources.

168. (C) Hypertension
Reserpine, an alkaloid extracted from the roots of Rauvolfia serpentina, was a groundbreaking drug for the treatment of hypertension (high blood pressure). By acting on the sympathetic nervous system, it helps lower blood pressure and has a calming effect, also making it useful for treating mental disorders. Its discovery in the mid-20th century demonstrated the potential of traditional medicinal plants to provide highly effective solutions for modern cardiovascular health.

169. (B) P-4, Q-1, R-2, S-3
Ocimum sanctum (Tulsi) is an adaptogen for colds, while Ricinus communis provides purgative oil. Piper nigrum is a spice and bio-enhancer, and Holarrhena antidysenterica is used for dysentery. Each of these plants has a specific, well-documented role in traditional and modern health practices. Understanding their primary properties is essential for correctly applying botanical knowledge in medicine and nutrition to address a wide range of human health needs.

170. (B) The principle of 'like cures like' using highly diluted substances.
The Homeopathic system of medicine is based on the principle that a substance that causes symptoms in a healthy person can cure similar symptoms in a sick person, known as "like cures like." Treatments involve using extremely diluted versions of these substances to trigger the body's natural healing ability. This unique approach focuses on treating the individual as a whole rather than just the isolated symptoms of a disease.

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171. (A) Both A and R are true and R is the correct explanation of A.
Somatic hybridization allows for the creation of hybrids between sexually incompatible species by bypassing the normal reproductive process. Scientists fuse the protoplasts (cells without walls) of two different species in a laboratory to combine their genetic material. This technique is a powerful tool in plant biotechnology, enabling the transfer of desirable traits like disease resistance between species that cannot naturally interbreed, expanding the possibilities for crop improvement.

172. (C) Anther/Pollen culture
Anther or pollen culture is the most suitable technique for producing haploid plants, which have only one set of chromosomes. These plants are regenerated from the microspores within the anther using tissue culture methods. Haploids are highly valuable in plant breeding because they allow for the rapid creation of homozygous diploid lines through chromosome doubling, significantly shortening the time needed to develop and stabilize new crop varieties with desirable traits.

173. (D) Spray herbicides without harming the target crop.
A transgenic plant engineered for glyphosate tolerance allows farmers to spray this broad-spectrum herbicide on their fields to kill weeds without damaging the crop itself. This simplifies weed management and can reduce the need for multiple applications of different herbicides or intensive mechanical weeding.

industrial applications like biodiesel production. Additionally, the remaining soybean meal is a vital protein source for animal feed. Its classification as an oilseed reflects its primary economic role in fulfilling the world's demand for high-quality vegetable oils and protein-rich food products.

239. (C) Produces beta-carotene, a Vitamin A precursor.
Golden Rice is a transgenic variety of rice engineered to produce beta-carotene, which the human body converts into Vitamin A. It was developed as a biofortified food to help combat Vitamin A deficiency, which is a major health problem in many developing countries where rice is a staple food. This application of biotechnology demonstrates how the genetic modification of crops can directly address global nutritional challenges and improve the health and well-being of vulnerable populations.

240. (B) Use in language, ritual, and art.
Ethnobotany is a comprehensive field that studies all interactions between humans and plants, including their roles in food, medicine, and shelter, as well as their cultural significance in language, rituals, and art. It explores how plants are woven into the spiritual and creative lives of people. This broad definition ensures that the discipline captures the full range of human-plant relationships, reflecting the deep and multifaceted ways that botanical resources shape and are shaped by human cultures.

241. (A) Ethnotoxicology
Ethnotoxicology is the specific branch of ethnobotany that would study the traditional use of plant-based fish poisons. Many indigenous cultures have identified specific plants containing toxins that, when released into water, paralyze or stun fish without making them harmful for human consumption. This sub-discipline explores the chemical nature of these poisons, the traditional techniques for their preparation and use, and the cultural context of hunting and fishing practices that rely on these potent botanical agents.

242. (B) Totem
A plant species believed to be the ancestor or spiritual emblem of a clan is known as a totem. Totemism creates a deep spiritual and social connection between a group of people and a specific species, often resulting in strict rules against harming or cutting it. This traditional belief system serves as a powerful mechanism for conservation, ensuring that the totem species is respected and protected by the community, thereby preserving both cultural identity and local biological diversity.

243. (B) Terminalia arjuna
The bark of Terminalia arjuna is renowned in traditional Indian medicine, particularly Ayurveda, for its exceptional benefits for heart health. It is used as a powerful cardiotonic that strengthens the heart muscle, improves its pumping efficiency, and helps regulate blood pressure. The long history of using Arjuna bark for cardiovascular support is backed by centuries of clinical observation and modern research, highlighting its importance as a primary natural remedy for maintaining and improving heart function.

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244. (A) Opiates
The latex of Papaver somniferum is the source of a class of powerful alkaloids known as opiates, which include morphine, codeine, and thebaine. These compounds are highly effective analgesics that act on the central nervous system to relieve severe pain. While essential in modern medicine for pain management, opiates also have a high potential for addiction. The study of these compounds is a major part of ethnobotany and pharmacology, reflecting their significant therapeutic and social impact globally.

245. (C) Withania somnifera
Triphala is a specific Ayurvedic formulation that consists of the dried fruits of three trees: Terminalia chebula, Terminalia bellerica, and Emblica officinalis. While Withania somnifera (Ashwagandha) is a very important and popular medicinal plant in Ayurveda, it is not a constituent of the Triphala formula. Understanding the precise ingredients of such classic formulas is essential for their correct application in traditional healthcare and for recognizing the specific therapeutic purposes for which they were originally developed.

false. However, the second statement is true, as the primary traditional and modern use of Aloe vera gel is external, for soothing burns, wounds, and various skin irritations. Its cooling and healing properties have made it one of the most popular and effective natural skin care ingredients worldwide for generations.

292. (C) P-3, Q-1, R-4, S-2
Withania somnifera is an adaptogen, while Terminalia arjuna is a cardiotonic. Azadirachta indica is used as an insecticide and for skin care, and Papaver somniferum is the source of the analgesic opium. Correctly matching these plants with their primary traditional uses is essential for understanding their therapeutic roles in different medical systems. This knowledge highlights the specific and diverse ways that botanical resources are utilized to address a wide range of human health and environmental needs.

293. (C) A piece of tissue placed into a nutrient medium to start a culture.
In plant tissue culture, an explant is a small, sterile piece of tissue, such as a leaf segment or root tip, that is removed from a parent plant and placed into a nutrient-rich medium to initiate a culture. The success of micropropagation and other tissue culture techniques relies on the explant's ability to divide and regenerate through totipotency. Choosing the right part of the plant to use as an explant is critical for achieving successful growth and regeneration.

294. (D) Ethnotaxonomy
A researcher studying the names and classification systems used for plants by a specific indigenous community is working in the field of ethnotaxonomy. This area of ethnobotany explores the logic and cultural context behind folk classification, which is often based on the practical use or physical characteristics of the plants. Understanding ethnotaxonomy is vital for documenting indigenous knowledge and recognizing the sophisticated biological understanding that traditional societies have developed about their local botanical environment over many generations.

295. (A) Direct cell division and differentiation.
The primary role of growth regulators like auxins and cytokinins in a plant tissue culture medium is to direct cell division and differentiation. By carefully adjusting the ratios of these hormones, scientists can induce an explant to form a callus or to develop specific organs like shoots and roots. This precise control over the developmental processes of plant cells is what makes it possible to successfully regenerate complete, healthy plants from small tissue samples in a laboratory setting.

296. (B) Drinking water that has been stored in a tumbler made from the wood.
The heartwood of Pterocarpus marsupium is traditionally used to manage diabetes by drinking water that has been stored overnight in a tumbler made from the wood. Bioactive compounds like epicatechin leach from the wood into the water, and when consumed, they help regulate blood sugar levels. This unique delivery method is a well-known ethnobotanical practice, demonstrating how traditional knowledge utilizes the specific chemical properties of woods to provide simple and effective natural treatments for chronic health conditions.

297. (B) 1 and 2 only
Transgenic plants are indeed created by introducing genes from different species, and phytoremediation is the use of plants to clean up environmental pollutants. However, somatic hybridization is an advanced laboratory technique involving the fusion of protoplasts, not a term for natural sexual reproduction. Therefore, only the first two statements are correct. Understanding these specific biotechnological terms is essential for accurately describing the various ways that plants are manipulated and utilized in modern science and environmental management today.

298. (B) Ocimum sanctum
In India, Ocimum sanctum, or Tulsi, is revered as a sacred plant and is widely grown in households for its exceptional medicinal properties. It is a common remedy for coughs, colds, and respiratory issues, and is also valued for its adaptogenic and antimicrobial benefits. Tulsi's dual role as a religious icon and a trusted natural medicine makes it one of the most important and culturally significant plants in traditional Indian healthcare and daily domestic life.

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identify Jatropha for biofuel, Pterocarpus for wood used in diabetes management, and Piper nigrum as a spice, reflecting the specific and diverse uses of these plants.

254. (D) Statement I is false, but Statement II is true.
Industrial fermentation can occur under both aerobic and anaerobic conditions, depending on the microorganism and the desired product. Therefore, the first statement is false. However, the second statement is true, as industrial fermenters are specifically designed to precisely control environmental variables such as temperature, pH, and aeration. This control is essential for optimizing the production of valuable biological substances like antibiotics, enzymes, and biofuels on a large scale in a consistent and efficient manner.

255. (C) G. Haberlandt
The concept of totipotency, the ability of a single plant cell to regenerate into a complete organism, was first proposed by the German botanist Gottlieb Haberlandt in 1902. Although he was not successful in his own attempts to culture plant tissues, his visionary idea laid the scientific foundation for all future work in plant tissue culture and biotechnology. His work established the theoretical possibility of regenerating entire plants from individual cells, a principle that is now used extensively in modern science.

256. (D) The apical meristem
To obtain virus-free plants from an infected parent, the apical meristem is the most appropriate explant to use. The very tip of the shoot is often free from viruses because the rapid division of meristematic cells outpaces the movement of the virus through the plant's developing vascular system. By carefully isolating and culturing this small healthy segment, scientists can regenerate completely disease-free clones of valuable plant varieties, ensuring the health and productivity of the resulting plants in agricultural systems.

257. (A) Somatic hybridization
The creation of a "pomato" by fusing the protoplasts of a potato and a tomato is a classic application of somatic hybridization. This technique allows for the combination of genetic material from two different species that cannot naturally crossbreed. While the resulting hybrid may not always be a commercially successful crop, the process demonstrates the power of biotechnology to bypass natural reproductive barriers and create unique new plant varieties with combined traits from distantly related taxonomic groups.

258. (B) Wheat
Wheat is a major cereal crop that is typically grown during the Rabi (winter) season in many regions, including India. It is sown in the late autumn and harvested in the spring. Wheat is a staple food for a large portion of the world's population, providing a primary source of carbohydrates. Its seasonal cultivation is a critical part of the agricultural cycle, ensuring a steady supply of energy-rich grain for food production and global security.

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259. (C) Ethno-gynaecology
Ethno-gynaecology is the branch of ethnobotany that focuses on the traditional knowledge and use of plants for women's health issues, including reproductive health, pregnancy, and childbirth. This field documents how different cultures have used botanical remedies for generations to manage these specific health needs. Research in ethno-gynaecology is important for preserving traditional wisdom and for identifying safe, natural alternatives for managing women's health based on long-standing cultural medical practices and observations from around the world.

260. (B) 2 and 3 only
Rauvolfia serpentina is indeed commonly known as Sarpagandha, and its roots are the primary source of the alkaloid reserpine. Reserpine has a well-documented use in both traditional and modern medicine for lowering high blood pressure and treating mental disorders. Therefore, all three statements are correct, as they accurately describe the plant's common name, the source and function of its key medicinal compound, and its long-standing therapeutic value for treating serious cardiovascular and neurological conditions.

261. (D) A is false but R is true.
Ethnobotanical knowledge is not static; it is constantly evolving as cultural practices and environmental conditions change. People

continuously adapt their use of plants based on new needs, experiences, and the availability of botanical resources. While some traditional knowledge is passed down unchanged, much of it is refined or expanded over time. Understanding this dynamic nature is essential for ethnobotanists to accurately document and interpret how human-plant relationships continue to develop in different societies and ecosystems globally.

262. (B) Piper nigrum
Black pepper is the dried fruit of the Piper nigrum plant, a woody climber native to the tropical regions of India. The fruits, known as peppercorns, are harvested and dried to produce the pungent and aromatic spice used globally in cooking and traditional medicine. Ethnobotanically, black pepper is prized for its ability to enhance digestion and stimulate the appetite, making it one of the most important and economically significant spices in human history.

263. (D) Adding soil to the culture medium to provide nutrients.
Aseptic techniques in a tissue culture lab are designed to maintain a completely sterile environment and do not involve adding soil. Soil is a major source of microbial contamination and is never used in the refined nutrient media used for tissue culture. Instead, media are sterilized in autoclaves, and all work is done in laminar air flow hoods using surface-sterilized explants. These rigorous procedures ensure that only the desired plant tissue grows, free from competition by bacteria and fungi.

264. (A) Its aromatic heartwood and oil.
The primary product of economic and ethnobotanical importance from Santalum album, or sandalwood, is its fragrant heartwood and the essential oil extracted from it. Sandalwood has been highly valued for thousands of years in religious rituals, traditional medicine, and perfumery for its unique cooling and aromatic properties. Due to its slow growth and high global demand, the tree is one of the most precious botanical resources, leading to strict regulations and conservation efforts to protect it.

265. (C) To obtain haploid plants for breeding.
The main purpose of anther culture is to produce haploid plants from immature pollen grains. These haploids contain only one set of chromosomes, making it possible to quickly create completely homozygous diploid lines through chromosome doubling. This technique significantly speeds up the plant breeding process, allowing researchers to develop and stabilize new crop varieties with desirable and uniform traits much faster than through traditional breeding methods alone, which is vital for modern agricultural improvement.

266. (B) A plant that absorbs and metabolizes organic pollutants from contaminated soil.
In phytoremediation, a plant plays a key role by absorbing environmental pollutants through its roots and either storing them or breaking them down into less harmful substances through its internal metabolic processes. This biological approach to environmental cleanup utilizes the natural capabilities of specific plant species to treat contaminated soil and water. It offers a sustainable, cost-effective, and eco-friendly alternative to mechanical and chemical remediation methods, helping to restore polluted ecosystems and protect the health of local communities.

267. (A) Q, P, R, S
In a logical plant breeding sequence, a hybrid is first created by crossing two parent lines. Next, anther culture is used to produce haploid plants from the hybrid's pollen. These haploids then undergo chromosome doubling to create homozygous diploid lines. Finally, these uniform lines are selected for their superior traits and released as a new variety. This systematic process significantly shortens the time needed to develop stable and improved crop varieties with consistent and desirable characteristics for agricultural use.

268. (D) Protein
In the context of economic botany, pulses are highly valued because they are an essential source of dietary protein for humans. They are especially important in regions where animal protein is less accessible or for people following vegetarian diets. Additionally, pulses are beneficial in agriculture as they fix nitrogen in the soil, improving fertility and reducing the need for chemical fertilizers.

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Their dual role as a nutritional staple and a soil-enriching crop makes them vital for sustainable global food systems.

269. (B) Atropine
The historical use of Atropa belladonna to dilate the pupils is due to the presence of the alkaloid atropine. Atropine acts as a mydriatic by relaxing the muscles of the eye, causing the pupil to expand. While used cosmetically in the past, it remains an essential drug in modern ophthalmology for diagnostic eye examinations and surgery. The extraction and standardization of atropine from the belladonna plant illustrate the lasting medical importance of botanical chemical compounds.

270. (C) Statement I is true, but Statement II is false.
Totipotency is the ability of a plant cell to regenerate into a complete plant, which is accurately stated in the first statement. However, this ability is not lost when a cell differentiates; under the right laboratory conditions, many specialized plant cells can be induced to return to an undifferentiated state and then form a new plant. This remarkable biological plasticity is the fundamental principle that allows for successful plant tissue culture and the regeneration of clones from various tissues.

271. (B) P-3, Q-4, R-1, S-2
Azadirachta indica is the botanical name for Neem, and Ocimum sanctum refers to Tulsi. Lawsonia inermis is the source of henna, and Allium sativum is the scientific name for garlic. Correctly matching these botanical names with their common counterparts is essential for scientific communication and for understanding the specific medicinal, industrial, and cultural roles that these important plant species play in both traditional societies and modern applications across the world today.

272. (B) Ethnoecology
Ethnoecology is the study of how indigenous and traditional societies perceive and manage their local ecosystems. It focuses on the traditional knowledge that these cultures have developed over generations regarding plant and animal life, climate patterns, and sustainable resource management. Understanding ethnoecology is vital for developing effective conservation strategies that respect and integrate traditional wisdom with modern environmental science, helping to protect both the natural world and the cultural heritage of the people who live within it.

273. (C) Cultural and spiritual beliefs, such as totemism.
Wildlife protection in many tribal communities is deeply rooted in cultural and spiritual beliefs rather than modern laws or economic incentives. For example, totemism leads people to revere and protect specific species as sacred emblems or ancestors. These deep-seated traditions create a strong and lasting commitment to conservation that is integrated into the social fabric of the community. Such traditional practices have effectively protected biodiversity and important habitats for generations, demonstrating the power of cultural values in environmental stewardship.

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274. (D) The poison and stimulant strychnine.
Strychnos nux-vomica is ethnobotanically significant as the source of strychnine, a potent alkaloid that acts as both a powerful stimulant and a deadly poison. Historically used in carefully controlled minute doses for various ailments, it is now primarily known for its lethal effect on the nervous system. The plant's study in ethnobotany highlights the sophisticated knowledge traditional societies had regarding the most powerful toxins in nature and how they could be used for both beneficial and harmful purposes.

275. (A) Emblica officinalis (Amla)
Emblica officinalis, or Amla, is a well-known traditional remedy for jaundice and other liver-related disorders. It possesses hepatoprotective properties that help support and restore liver function and aid in detoxification. Amla's high antioxidant content and its role in improving digestion and metabolism make it an essential botanical treatment for liver health in many traditional medicine systems, where it is used to manage hepatitis and promote overall systemic well-being and recovery.

276. (B) A small, sterile piece of plant tissue used to initiate a culture.
An explant is any small portion of a plant, such as a leaf segment, root tip, or bud, that is removed and placed on a sterile nutrient medium to

start a tissue culture. The success of the culture depends on the explant's ability to regenerate through totipotency. Selecting the appropriate tissue to use as an explant is critical for achieving specific biotechnological goals, such as clonal propagation, genetic modification, or the production of valuable plant-derived compounds in the laboratory.

277. (B) Create hybrids between species that cannot be crossed sexually.
The main goal of somatic hybridization is to produce hybrids between plant species that are sexually incompatible and cannot naturally interbreed. By fusing the protoplasts (cells without walls) of two different species in a laboratory, scientists can combine their genetic material to create unique new varieties. This technique is a powerful tool in plant biotechnology for transferring desirable traits like disease resistance and stress tolerance across distant taxonomic boundaries, expanding the possibilities for crop improvement and research.

278. (A) It contains a gene or genes inserted through genetic engineering.
A transgenic plant is an organism that has been genetically modified by inserting one or more genes from another species into its genome. This is done to give the plant beneficial new traits, such as resistance to pests, tolerance to herbicides, or improved nutritional content. This technology allows for precise genetic changes that are often impossible to achieve through traditional cross-breeding methods, providing a powerful tool for modern agriculture to enhance crop productivity and sustainability.

279. (B) Ethnoveterinary medicine
Ethnoveterinary medicine is the branch of ethnobotany that focuses on the traditional knowledge and practices used by indigenous cultures to maintain the health and treat the diseases of their animals. This field documents the use of specific plants, minerals, and traditional techniques for veterinary care. Research in this area is vital for preserving traditional wisdom and for developing sustainable, accessible, and affordable animal healthcare solutions that are based on locally available botanical and natural resources.

280. (B) 1 and 2 only
Ethnotoxicology is the study of plant poisons, and ethnocosmetics focuses on plant use for personal care. However, ethno-ophthalmology specifically concerns treatments for eye ailments, not skeletal injuries, which is ethno-orthopaedics. Correctly matching these sub-disciplines is essential for understanding the specialized branches of traditional botanical knowledge that address different human needs. While the first two pairings are correct, the third must be accurately defined to reflect its true focus on ocular health and traditional treatments for the eyes.

281. (D) Vata, Pitta, Kapha
The Ayurvedic system of medicine is based on the balance of three fundamental biological energies or humors known as doshas: Vata, Pitta, and Kapha. Each person has a unique combination of these doshas, and health is defined as their perfect balance. Ayurvedic treatments use combinations of herbs, diet, and lifestyle changes to correct imbalances and restore health, making it one of the most comprehensive and enduring traditional medical systems in the world today.

282. (A) Both A and R are true and R is the correct explanation of A.
The domestication of plants like wheat and rice was a pivotal event in human history because it allowed people to move from a nomadic hunter-gatherer lifestyle to a sedentary agricultural existence. This transition led to the development of stable food supplies, permanent settlements, and the rise of complex civilizations. Both statements are accurate, as they highlight the fundamental role that plant domestication played in shaping the evolution of human society and the foundations of global agriculture.

283. (B) Rhizome
Ginger is obtained from the aromatic underground stem, known as a rhizome, of the Zingiber officinale plant. The rhizome stores nutrients for the plant and contains the bioactive oils and phenolic compounds responsible for ginger's characteristic pungent flavour and medicinal properties. Ethnobotanically, this rhizome is used worldwide as both a versatile spice and a powerful remedy for digestive issues, nausea, and respiratory conditions, making it

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one of the most important medicinal plants in human history.

284. (A) Ocimum sanctum
A traditional remedy for asthma and bronchial inflammation often involves a tea or decoction made from the leaves of Ocimum sanctum, commonly known as Tulsi. Tulsi contains essential oils and compounds that have significant anti-inflammatory, expectorant, and antimicrobial effects, helping to clear the respiratory tract and ease breathing. This plant is a staple in traditional medicine and household remedies for its safety and effectiveness in managing various respiratory and cold symptoms naturally and accessibly.

285. (C) Clonal propagation of orchids.
Industrial fermenters are used for the mass production of antibiotics, enzymes, and alcoholic beverages by microorganisms. However, they are not used for the clonal propagation of orchids, which is achieved through plant tissue culture on solid or liquid nutrient media in specialized laboratory containers. Fermenters are designed to grow and manage microbial cultures in large volumes, while micropropagation focuses on the controlled growth and regeneration of complex plant tissues to produce whole, individual plantlets.

286. (D) Organs like shoots and roots from a callus
Organogenesis in plant tissue culture is the process where organs such as shoots and roots are developed from a mass of undifferentiated callus cells or directly from an explant. This development is precisely controlled by adjusting the concentrations of plant hormones like auxins and cytokinins in the nutrient medium. Organogenesis is a critical step in regenerating whole, functional plants from cultured tissues, allowing for the successful micropropagation and genetic improvement of various plant species in the laboratory.

287. (A) The long-term conservation of germplasm.
A key application of cryopreservation is the long-term conservation of plant germplasm at the ultra-low temperature of liquid nitrogen. This technique allows for the preservation of seeds, embryos, and tissue samples in a viable state for many years, preventing genetic degradation and protecting global biodiversity. Cryopreservation is an essential tool for maintaining the genetic resources of crops and endangered species, ensuring that their unique traits remain available for future scientific research, plant breeding, and environmental conservation efforts.

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288. (B) Soybean
Soybean is a major oilseed crop that is valued for its seeds, which are a primary global source of high-quality vegetable oil. The oil extracted from soybeans is used extensively for cooking, food processing, and the production of biodiesel. Additionally, the remaining soybean meal is a vital source of protein for animal feed. Its dual role as a major oilseed and protein source makes it one of the most economically and nutritionally important crops in modern global agriculture.

289. (B) Papaver somniferum
Papaver somniferum, the opium poppy, is the plant source for powerful alkaloids such as opium, morphine, and codeine. These compounds are extracted from the dried latex of the plant's unripe fruit capsule and are essential in modern medicine for managing severe pain. The study of the poppy plant is a significant part of ethnobotany and pharmacology, reflecting its long history of both therapeutic use and the serious social challenges associated with its addictive properties globally.

290. (A) The comparative study of traditional medical systems of various cultures.
Ethnomedicine is the interdisciplinary study of how different cultural groups perceive and treat various illnesses and maintain health. It compares the traditional medical systems of various societies, documenting their unique philosophies, diagnostic methods, and use of natural remedies, primarily from plants. This field provides deep insights into the cultural context of health and healing and is essential for preserving traditional medical wisdom and identifying potentially effective natural treatments for modern scientific investigation and validation.

291. (D) Statement I is false, but Statement II is true.
While Aloe vera gel has some minor internal uses, it is not a primary or potent medicine for heart disease; therefore, the first statement is

CHAPTER 08
Cell biology and Evolution

1. Which of the following best defines the cell envelope?
(A) The collective layer comprising the cell's plasma membrane and its internal cytoplasm.
(B) The outer layers including the plasma membrane, cell wall, and an outer membrane.
(C) The specific structure that exclusively houses and protects the genetic material.
(D) The fluid-filled region located between the nucleus and the plasma membrane.

2. Which statement accurately describes a primary function of the plant cell wall?
(A) It provides structural support and protection against osmotic stress.
(B) It regulates the passage of all ions and small molecules into the cell.
(C) It is the primary site of cellular respiration and ATP synthesis.
(D) It synthesizes specialized proteins for export from the internal cell.

3. According to the fluid mosaic model, plasma membranes are best described as:
(A) A static framework of proteins fixed firmly within a single lipid monolayer.
(B) A solid, impermeable barrier composed entirely of complex carbohydrates.
(C) A fluid bilayer of phospholipids with mobile associated proteins.
(D) A triple-layered protein system that actively pumps various lipids.

4. Read the following statements and select the correct option.
Statement I: The lipid bilayer of the plasma membrane is amphipathic, with hydrophilic heads facing outwards and hydrophobic tails facing inwards.
Statement II: This arrangement creates a barrier that is permeable to large, charged molecules.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

5. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Integral membrane proteins are embedded within the lipid bilayer, often spanning the entire membrane.
Reason (R): These proteins have hydrophobic regions that interact with the fatty acid tails of the phospholipids and hydrophilic regions that interact with the aqueous environment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

6. The net movement of a substance from a region of higher concentration to a region of lower concentration is known as:
(A) Active transport
(B) Diffusion
(C) Osmosis
(D) Endocytosis

7. What happens to a plant cell when it is placed in a hypertonic solution?
(A) The cell will swell and may burst due to the rapid influx of water.
(B) The cell remains unchanged as the wall prevents any water movement.
(C) The cell will actively pump salts out to equalize the concentration.
(D) The cell loses water and the membrane pulls from the cell wall.

8. Gated ion channels are proteins that:
(A) Open or close for ion diffusion in response to specific stimuli.

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299. (A) Both A and R are true and R is the correct explanation of A.
Cryopreservation uses liquid nitrogen because it provides an ultra-low temperature of -196°C, which completely arrests all metabolic and biological activities within the plant cells. This extreme cold also prevents the formation of large ice crystals that could damage delicate cellular structures. Both statements are accurate, as they describe the technique and the essential scientific reasons why liquid nitrogen is used to ensure the long-term viability and genetic stability of preserved plant germplasm and biodiversity.

300. (B) Gram
Gram is a pulse crop, not a cereal. Cereals like wheat, rice, and maize are members of the grass family and are primarily valued as sources of carbohydrates. Pulses, on the other hand, belong to the legume family and are essential sources of dietary protein. Understanding the distinction between these major crop categories is fundamental in economic botany and agriculture, as it determines their nutritional roles and how they are grown and utilized in global food systems.

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246. (D) Holarrhena antidysenterica
To treat a patient with amoebic dysentery, a traditional practitioner would most likely use preparations from Holarrhena antidysenterica. The bark and seeds of this plant contain potent alkaloids that are specifically effective against the parasites responsible for the infection. Its use is well-documented in various folk medicine systems, providing a reliable and targeted botanical treatment for severe gastrointestinal issues where traditional knowledge has identified the most effective natural agents for managing such conditions.

247. (C) Microorganisms compete for nutrients and can produce toxins harmful to the plant tissue.
A sterile environment is absolutely necessary for plant tissue culture because the nutrient-rich medium used is also an ideal growth environment for bacteria and fungi. These microorganisms grow much faster than plant cells and will quickly outcompete them for nutrients. Additionally, many microorganisms produce toxins that can kill the sensitive plant tissue. Maintaining sterility through techniques like autoclaving and laminar air flow is essential to ensure that the plant tissues can successfully grow and regenerate.

248. (B) Haploid plants
The primary advantage of anther culture is the production of haploid plants, which contain only one set of chromosomes from the microspores. These haploids are extremely valuable in plant breeding because they can be treated to double their chromosome number, creating homozygous diploid lines in a single generation. This technique significantly shortens the time required to develop and stabilize new plant varieties with desirable and consistent traits, making it a powerful tool for modern agricultural and botanical research.

249. (B) Using plants to absorb and accumulate heavy metals from soil.
Using plants to absorb and accumulate heavy metals from contaminated soil is a key process of phytoremediation known as phytoextraction. Certain plant species have the natural ability to take up these toxins through their roots and store them in their shoots and leaves. This sustainable and cost-effective technology allows for the removal of harmful pollutants from the environment, utilizing the biological capabilities of plants to clean up contaminated sites and restore them for safe use and ecological health.

250. (A) P-4, Q-2, R-1, S-3
Meristem culture is used to produce virus-free plants, while anther culture focuses on the production of haploids for breeding. Somatic hybridization is a technique to overcome sexual incompatibility by fusing protoplasts, and cryopreservation is used for the long-term storage of plant germplasm in liquid nitrogen. Correctly matching these techniques with their primary goals is essential for understanding and applying modern plant biotechnology to solve various agricultural, conservation, and research challenges effectively and precisely.

251. (B) Lawsonia inermis
Lawsonia inermis is the botanical source of henna, a natural dye traditionally used for body art and hair colouring. The leaves of the plant are harvested, dried, and ground into a fine powder that, when mixed with water, releases a reddish-brown pigment. Henna has a long history of use in ethnocosmetics across many cultures and is also valued for its cooling properties and its use in traditional medicine to treat various skin conditions naturally.

252. (A) A specific group of people or culture.
The term "ethno" in ethnobotany refers to a specific group of people or a particular culture. It signifies that the discipline is focused on the knowledge, perceptions, and uses of plants within the context of human societies. This cultural focus is what distinguishes ethnobotany from traditional botany, as it emphasizes the deep and complex relationships that exist between different human groups and the plant world, documenting how culture shapes our understanding and use of nature.

253. (C) Santalum album - Edible fruit
Santalum album, or sandalwood, is primarily valued for its aromatic heartwood and the essential oil extracted from it, rather than for its fruit. While some parts of the tree may have minor uses, its major economic and ethnobotanical importance lies in the perfume, religious, and medicinal industries. The other pairings correctly

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(B) Actively pump ions against their concentration gradient using ATP.
(C) Are always open, allowing for the free diffusion of any ionic species.
(D) Synthesize ions within the cytoplasm for immediate cellular transport.

9. Which of the following is an incorrect statement regarding active transport?
(A) It requires energy, typically in the form of ATP.
(B) It moves substances against their concentration gradient.
(C) It necessitates the constant movement of water across a membrane.
(D) It is mediated by specific carrier proteins or metabolic pumps.

10. Match the following items in List I with those in List II regarding membrane transport mechanisms and select the correct option.
List I: (Mechanism)
P. Simple Diffusion
Q. Osmosis
R. Active Transport
S. Ion Channel
List II: (Characteristic)
1. Movement of water across a semipermeable membrane
2. ATP-dependent movement against a concentration gradient
3. Gated or non-gated passage for specific ions
4. Passive movement of nonpolar molecules down a concentration gradient
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

11. The mechanism of sorting proteins destined for different organelles primarily begins in which cellular component?
(A) The nucleus, specifically during the process of DNA transcription.
(B) The plasma membrane, immediately upon protein secretion activities.
(C) The mitochondria, where metabolic energy is provided for sorting.
(D) The Golgi complex, where proteins are modified and packaged.

12. The electrical property of a membrane, known as the membrane potential, is primarily established by:
(A) The equal distribution of all essential ions across the biological membrane.
(B) Differential distribution of Na^+ and K^+ ions across the membrane.
(C) The flow of electrons along the lipid bilayer within the membrane structure.
(D) The neutral charge maintained by the phospholipid heads in the bilayer.

13. The primary function of the Golgi complex is:
(A) Synthesis of essential lipids and steroid hormones.
(B) Production of ATP through aerobic cellular respiration.
(C) Processing, packaging, and sorting of proteins and lipids.
(D) Degradation of cellular waste materials using acid hydrolases.

14. The inner membrane of the mitochondria is highly folded into cristae to:
(A) Decrease the total surface area available for simple diffusion.
(B) Increase the volume of the internal mitochondrial matrix space.
(C) Provide a rigid internal structure to the double-membrane organelle.
(D) Maximize surface area for the transport chain and ATP synthesis.

15. Consider the following statements about chloroplasts:
1. They are the site of photosynthesis in plant cells.
2. They contain their own DNA and ribosomes.
3. The light-independent reactions (Calvin cycle) occur in the thylakoid membrane.
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

16. Peroxisomes are single-membrane-bound organelles primarily involved in:
(A) The synthesis of specialized proteins for extracellular secretion.

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54. The ultimate source of all new genetic variation in a population is:
(A) Adaptation
(B) Mutation
(C) Natural selection
(D) Gene flow

55. Read the following statements and select the correct option.
Statement I: Natural selection acts on individuals, but only populations evolve.
Statement II: Natural selection creates new variations in a population to suit a changing environment.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

56. The idea that mutations arise randomly, without regard to their usefulness, is known as:
(A) The spontaneity of mutations.
(B) Directed mutation
(C) Inheritance of acquired characteristics
(D) Adaptive radiation

57. The "evolutionary synthesis" refers to the:
(A) Total rejection of Darwinism in favor of Lamarckian principles.
(B) Idea that evolution only occurs in large and rapid bursts.
(C) Integration of natural selection with Mendelian genetics.
(D) Study of various fossil evidences exclusively in geology.

58. A trait that increases an organism's fitness in its environment is called:
(A) An adaptation
(B) A variation
(C) A mutation
(D) A struggle

59. Which concept is NOT part of Darwin's theory of evolution by natural selection?
(A) Variation exists within populations.
(B) There is a struggle for existence.
(C) Individuals with favorable traits are more likely to survive and reproduce.
(D) Organisms inherit acquired characteristics.

60. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The "evolutionary synthesis" was a major turning point in the history of evolutionary thought.
Reason (R): It reconciled the particulate nature of Mendelian inheritance with the gradual process of evolution by natural selection.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

61. Which of the following is NOT a component of the cell envelope in a typical Gram-negative bacterium?
(A) Plasma membrane
(B) An outer membrane
(C) A thick peptidoglycan layer
(D) Periplasmic space

62. The selective permeability of the plasma membrane is primarily due to the:
(A) Presence of cholesterol molecules only.
(B) Glycocalyx on the outer surface.
(C) Cytoskeletal filaments attached to the inner surface.
(D) Hydrophobic core of the lipid bilayer.

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63. Which model of the plasma membrane was proposed first and depicted a static, "sandwich-like" structure with proteins coating a lipid bilayer?
(A) Davson-Danielli Model
(B) Fluid Mosaic Model
(C) Singer-Nicolson Model
(D) Gorter-Grendel Model

64. A cell needs to move Ca^{2+} ions from the cytoplasm, where the concentration is low, to the extracellular fluid, where the concentration is high. This process would require:
(A) Simple diffusion across the bilayer.
(B) Active transport via an ion pump.
(C) Facilitated diffusion via a channel.
(D) The passive process of osmosis.

promoter
3. Loosely packed, transcriptionally active chromatin
4. Tightly packed, largely inactive chromatin

(A) P-1, Q-2, R-4, S-3
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-2, S-4

26. What is the significance of "interrupted genes" containing introns and exons?
(A) It allows alternative splicing for multiple protein production.
(B) Introns are translated into functional proteins, while exons are removed.
(C) It simplifies the process of DNA replication within eukaryotic cells.
(D) It ensures that genes are always expressed at a constant cellular level.

27. Heterochromatin is generally characterized by all of the following EXCEPT:
(A) It is highly condensed.
(B) It replicates late in the S phase.
(C) It is often located at the centromeres and telomeres.
(D) It contains a high density of active genes.

28. The term "chromosome walking" refers to a technique used to:
(A) Visualize chromosomes during the process of mitotic division.
(B) Clone genes located near a known DNA marker sequence.
(C) Analyze the specific banding pattern of a condensed chromosome.
(D) Count the total number of chromosomes in a eukaryotic cell.

29. Transposons, or "jumping genes," are sequences of DNA that can:
(A) Permanently fix the position of a gene on its chromosome.
(B) Only be transcribed into RNA but never replicated in DNA.
(C) Move from one location in the genome to another.
(D) Function primarily as the origin of chromosomal replication.

30. Consider the following statements regarding DNA:
1. Unique sequence DNA consists of nucleotide sequences that are represented only once in the genome.
2. Repetitive DNA consists of nucleotide sequences that are present in multiple copies.
3. Most protein-coding genes are found within the highly repetitive DNA fraction.

Which of the statements given above is/are correct?
(A) 3 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

31. The process of mitosis results in:
(A) Two genetically identical diploid cells.
(B) Four genetically different haploid cells.
(C) Two genetically different diploid cells.
(D) Four genetically identical diploid cells.

32. The process of meiosis is essential for sexual reproduction because it:
(A) Doubles the chromosome number in the resulting gametes.
(B) Creates haploid gametes by halving the chromosome number.
(C) Produces genetically identical daughter cells for tissue growth.
(D) Repairs damaged DNA segments within the somatic cell lines.

33. Which is an incorrect pairing of a cell cycle phase with its main event?
(A) G1 Phase – Cell growth and protein synthesis.
(B) G2 Phase – Preparation for meiosis.
(C) S Phase – DNA replication.
(D) M Phase – Chromosome segregation and cytokinesis.

34. Regulation of the cell cycle is primarily controlled by:
(A) The activity of cyclin-dependent kinases (CDKs) and cyclins.
(B) The specific concentration of glucose available in the cell.
(C) The total size of the cell's internal storage vacuole.

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(B) Breaking down fatty acids and detoxifying harmful substances.
(C) The storage of water, essential ions, and various cellular nutrients.
(D) The replication of the cell's genetic material in the cytoplasm.

17. Which of the following correctly pairs an organelle with its primary function?
(A) Ribosome – Internal lipid synthesis
(B) Endoplasmic Reticulum – Protein synthesis and lipid metabolism
(C) Lysosome – Photosynthesis process
(D) Vacuole – Cellular ATP production

18. What is the main function of a lysosome?
(A) Digestion of macromolecules and old organelles via hydrolases.
(B) It modifies and sorts proteins received from the endoplasmic reticulum.
(C) It is the primary site of DNA replication and transcription processes.
(D) It synthesizes ATP using a proton gradient across its single membrane.

19. The nucleus is separated from the cytoplasm by the nuclear envelope, which is characterized by being:
(A) A single, impermeable membrane protecting the genome.
(B) A structure composed entirely of specialized proteins.
(C) A double membrane perforated with nuclear pores.
(D) A fluid layer continuous with the Golgi apparatus sacs.

20. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Mitochondria and chloroplasts are considered semi-autonomous organelles.
Reason (R): They possess their own genetic material (DNA) and machinery for protein synthesis (ribosomes).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

21. A chromosome is structurally composed of:
(A) A single molecule of RNA and associated regulatory proteins.
(B) A lipid bilayer structure containing genetic information.
(C) A condensed molecule of DNA complexed with proteins.
(D) A chain of amino acids folded into a specific genetic shape.

22. Polytene chromosomes and lampbrush chromosomes are examples of:
(A) Standard mitotic chromosomes found in most somatic tissues.
(B) Special types of chromosomes with unique structures and roles.
(C) Chromosomes found exclusively in various prokaryotic cells.
(D) Artificial chromosomes created within a controlled laboratory.

23. The first level of DNA packaging in eukaryotic chromosomes involves the winding of DNA around a core of:
(A) Ribosomal proteins
(B) Single-strand binding proteins
(C) DNA polymerase
(D) Histone proteins

24. A karyotype is best described as:
(A) The organized profile of a person's chromosomes.
(B) The complete genetic sequence of an organism.
(C) The process of DNA replication.
(D) The pattern of gene expression in a cell.

25. Match the following terms in List I with their descriptions in List II regarding DNA and chromosome structure and select the correct option.
List I: (Term)
P. Euchromatin
Q. Heterochromatin
R. Operon
S. Transposon
List II: (Description)
1. A segment of DNA that can move to a new position in the genome
2. A functioning unit of DNA containing a cluster of genes under the control of a single

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45. Match the following chromosomal abnormalities in List I with their descriptions in List II and select the correct option.
List I: (Abnormality)
P. Deletion
Q. Duplication
R. Translocation
S. Aneuploidy
List II: (Description)
1. Presence of an extra copy of a chromosomal segment
2. An abnormal number of chromosomes (e.g., 2n+1)
3. Loss of a chromosomal segment
4. Movement of a segment from one chromosome to a non-homologous chromosome
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

46. Small, circular, self-replicating DNA molecules found in bacteria, separate from the main chromosome, are known as:
(A) Karyotypes
(B) Centromeres
(C) Introns
(D) Plasmids

47. Mendel's Law of Segregation states that:
(A) The two alleles for a character separate during gamete formation.
(B) Alleles for different traits are inherited independently of one another.
(C) Some alleles are dominant while others are recessive in expression.
(D) Genes are located on specific chromosomes within the nucleus.

48. When the phenotype of the heterozygote is intermediate between the phenotypes of the two homozygotes, this is an example of:
(A) Complete dominance
(B) Incomplete dominance
(C) Codominance
(D) Gene interaction

49. Polygenic inheritance is a mode of inheritance in which:
(A) A single gene affects multiple phenotypic traits.
(B) A single trait is controlled by two or more genes.
(C) Alleles are neither dominant nor recessive.
(D) Genes are located on the mitochondrial DNA.

50. Consider the following statements about Lamarck's theory of evolution:
1. It proposed that organisms have an innate drive to become more complex.
2. It included the concept of inheritance of acquired characteristics.
3. It emphasized the role of natural selection in driving evolutionary change.
Which of the statements given above is/are correct?
(A) 3 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

51. Who is credited with co-developing the theory of evolution by natural selection alongside Charles Darwin?
(A) Jean-Baptiste Lamarck
(B) Gregor Mendel
(C) Alfred Russel Wallace
(D) Thomas Malthus

52. In evolutionary terms, "fitness" is best defined as:
(A) The physical strength and speed of an individual.
(B) The ability of an organism to survive to reproductive age.
(C) The complexity of an organism's biological systems.
(D) The measure of an organism's reproductive success.

53. The concept that populations tend to produce more offspring than the environment can support, leading to a "struggle for existence," was a key component of:
(A) Lamarck's theory of use and disuse.
(B) Mendel's laws of inheritance.
(C) Darwin's theory of natural selection.
(D) The concept of polyploidy.

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into various proteins.
(B) It protects the DNA from any form of transcription activities.
(C) It allows genomic DNA to fit inside the small nucleus.
(D) It ensures that only repetitive DNA sequences are ever expressed.

94. What is the significance of the "cis-trans test of recombination"?
(A) It determines the physical distance between two genes on a chromosome.
(B) It is another name for a test cross in classical Mendelian genetics.
(C) It helps to define the functional unit of a gene, or cistron.
(D) It is used to create a detailed karyotype of an organism's genome.

95. The condition known as Down syndrome is an example of:
(A) Polyploidy, with a 3n chromosome number.
(B) A structural translocation.
(C) Aneuploidy, specifically Trisomy 21.
(D) A large chromosomal deletion.

96. The function of mitochondrial DNA primarily involves coding for:
(A) All proteins required by the mitochondrion for its internal structure.
(B) Proteins for the Golgi apparatus and endoplasmic reticulum organelles.
(C) Proteins for respiration and mitochondrial tRNAs and rRNAs.
(D) Genes related to the maintenance of cell shape and cellular motility.

97. In a classic Mendelian cross between two true-breeding parents for a single trait (e.g., PP x pp), the F2 generation will exhibit a phenotypic ratio of:
(A) 3:1
(B) 1:1
(C) 1:2:1
(D) 9:3:3:1

98. The emergence of evolutionary thought was significantly influenced by observations from geology and the fossil record, which suggested that:
(A) The Earth is only a few thousand years old in age.
(B) Species are fixed and unchanging in their forms.
(C) Earth is old, and species have changed over time.
(D) All fossils were formed in one catastrophic event.

99. Natural selection is the process by which:
(A) Suited organisms tend to survive and reproduce more successfully.
(B) Individuals can choose which traits to pass on to their biological offspring.
(C) Random events cause changes in the genetic makeup of a biological population.
(D) All individuals in a population slowly change in a coordinated and planned way.

100. Consider the following statements regarding the cell cycle:
1. Interphase is a resting stage where the cell does not perform any metabolic activity.
2. The S phase is characterized by the replication of the cell's DNA.
3. Control of the cell cycle is mediated by internal and external signals at specific checkpoints.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

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101. Which component of the cell envelope is responsible for maintaining the shape of a bacterial cell?
(A) The plasma membrane
(B) The cytoplasm
(C) The cell wall
(D) The flagellum

102. What distinguishes active transport from facilitated diffusion?
(A) Active transport requires energy input, while facilitated diffusion does not.
(B) Active transport moves substances down their concentration gradient in the cell.
(C) Facilitated diffusion requires a carrier protein, while active transport does not.
(D) Facilitated diffusion occurs only in plant

65. Match the following organelles in List I with their descriptions in List II and select the correct option.
List I: (Organelle)
P. Ribosome
Q. Smooth ER
R. Central Vacuole (plant)
S. Peroxisome
List II: (Description)
1. Toxin detoxification and lipid synthesis
2. Contains enzymes like catalase for breaking down H_2O_2
3. Site of protein synthesis
4. Maintains turgor pressure and stores water/ ions
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-2, S-3

66. The "cis" and "trans" faces of the Golgi complex are associated with:
(A) Receiving vesicles from the ER and shipping them out.
(B) Shipping vesicles out and receiving vesicles from the ER.
(C) The synthesis of cis and trans fatty acids in the cell.
(D) The import and export of water molecules for hydration.

67. Which of the following statements about the nucleus is incorrect?
(A) It contains the cell's primary genetic material.
(B) It is enclosed by a double membrane.
(C) It is the primary site of ATP synthesis.
(D) It is the site of ribosome subunit assembly.

68. Chromosome banding patterns, such as G-banding, are useful for:
(A) Determining the exact DNA sequence of the entire chromosome.
(B) Measuring the precise rate of gene transcription in a cell.
(C) Inducing targeted mutations at specific chromosomal loci.
(D) Identifying chromosomes and detecting structural abnormalities.

69. In the context of an operon, what is the function of the operator?
(A) It is the site where RNA polymerase binds to initiate transcription.
(B) It specifically codes for the synthesis of the repressor protein.
(C) A DNA sequence where a repressor binds to block transcription.
(D) It is the structural gene that codes for a specific enzyme.

70. The presence of unique and repetitive DNA is a characteristic feature of:
(A) Prokaryotic genomes only.
(B) Eukaryotic genomes.
(C) Viral genomes only.
(D) Plasmids.

71. What is the fundamental difference between mitosis and meiosis I?
(A) Chromosomes replicate during mitosis but not during meiosis I.
(B) Cytokinesis occurs in mitosis but not in meiosis I.
(C) Sister chromatids separate in meiosis I, but not in mitosis.
(D) Homologous chromosomes pair and separate in meiosis I.

72. A key checkpoint in the cell cycle, the G1/S checkpoint, determines if the cell should:
(A) Commit to DNA replication.
(B) Enter mitosis.
(C) Exit the cell cycle and enter G0.
(D) Undergo cytokinesis.

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73. If two genes are very far apart on the same chromosome, their recombination frequency is expected to be:
(A) Close to 0% in all offspring.
(B) Exactly 100% in all offspring.
(C) Close to 50%, behaving as unlinked.
(D) Always 25% in every offspring.

74. A chromosomal translocation is considered "reciprocal" when:
(A) Two non-homologous chromosomes exchange segments.
(B) A segment is lost from one chromosome.
(C) A segment moves from one location to another on the same chromosome.

(D) An entire chromosome moves to a new position.

75. Consider the following statements about extranuclear inheritance:
1. It follows typical Mendelian patterns of inheritance.
2. It involves genes located in mitochondria and chloroplasts.
3. In many species, it is uniparental, often inherited from the mother.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

76. In a dihybrid cross, Mendel's Law of Independent Assortment applies to genes that are:
(A) Located on the same chromosome and are very tightly linked.
(B) On different chromosomes or very far apart on one.
(C) Always expressed as an intermediate phenotype in offspring.
(D) Found only in the mitochondrial DNA of the eukaryotic cell.

77. Traits like human height and skin color, which show continuous variation, are typically the result of:
(A) A single gene with two alleles.
(B) A single dominant allele.
(C) Polygenic inheritance.
(D) Extranuclear inheritance.

78. Lamarck's concept of "use and disuse" proposed that:
(A) Traits acquired during an organism's life are passed to offspring.
(B) Mutations are the primary source of variation in a population.
(C) All organisms share a single common ancestor in evolutionary history.
(D) Used parts become stronger, while unused parts deteriorate.

79. Which concept is a cornerstone of Darwin's theory of natural selection?
(A) Differential survival and reproduction.
(B) The inheritance of acquired traits.
(C) A predetermined path of evolution.
(D) The sudden appearance of new species.

80. Arrange the following events of evolutionary thought in chronological order:
1. Publication of Darwin's "On the Origin of Species".
2. Proposal of the "evolutionary synthesis".
3. Lamarck's theory of inheritance of acquired characteristics.
4. Mendel's experiments on pea plants.

Choose the correct option:
(A) 3, 1, 4, 2
(B) 1, 3, 4, 2
(C) 3, 4, 1, 2
(D) 4, 1, 3, 2

81. A student observes a cell with a thick peptidoglycan cell wall and no nucleus. This cell is most likely a:
(A) Plant cell
(B) Gram-positive bacterium
(C) Fungal cell
(D) Protozoan

82. The electrical properties of a nerve cell membrane, such as the action potential, are primarily a function of:
(A) The rapid opening and closing of voltage-gated ion channels.
(B) The movement of lipids within the phospholipid bilayer membrane.
(C) The synthesis of proteins by ribosomes in the nerve cell cytoplasm.
(D) The mechanical support provided by the cytoskeletal network.

83. The regulation of intracellular transport ensures that proteins are delivered to their correct destinations. A failure in this system could lead to:
(A) Increased ATP production.
(B) A halt in DNA replication.
(C) Lysosomal proteins being secreted from the cell.
(D) The formation of a cell wall in an animal cell.

84. The Endoplasmic Reticulum (ER) is a network of membranes involved in protein and lipid

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synthesis. The rough ER is "rough" due to the presence of:
(A) Mitochondria
(B) Lysosomes
(C) Peroxisomes
(D) Ribosomes

85. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Eukaryotic genes contain non-coding sequences called introns.
Reason (R): The presence of introns allows for alternative splicing, which can generate multiple distinct proteins from a single gene.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

86. Which of the following is a key feature of a lampbrush chromosome?
(A) It represents the most condensed form of a chromosome during mitosis.
(B) DNA loops from the axis indicate high transcriptional activity.
(C) It is found in all somatic cells throughout the entire interphase.
(D) It completely lacks a centromere for spindle fiber attachment.

87. Which statement correctly distinguishes heterochromatin from euchromatin?
(A) Heterochromatin is gene-rich and actively transcribed, while euchromatin is gene-poor and silent.
(B) Euchromatin contains repetitive DNA, while heterochromatin contains unique sequence DNA.
(C) Heterochromatin is found only in prokaryotes, while euchromatin is found only in eukaryotes.
(D) Euchromatin is transcriptionally active; heterochromatin is silent.

88. The control of the cell cycle involves checkpoints that monitor the cell's status. The M checkpoint ensures that:
(A) All chromosomes are properly attached to the spindle fibers.
(B) DNA replication is complete throughout the entire nuclear genome.
(C) The cell has grown to a sufficient size for division to occur.
(D) The cell has accumulated enough nutrients for the division process.

89. A structural change in a chromosome that results in the loss of a terminal segment is called:
(A) Interstitial deletion
(B) Paracentric inversion
(C) Terminal deletion
(D) Robertsonian translocation

90. Match the following scientists in List I with their major contributions in List II and select the correct option.
List I: (Scientist)
P. Darwin
Q. Lamarck
R. Mendel
S. Singer & Nicolson
List II: (Contribution)
1. Laws of inheritance
2. Fluid Mosaic Model of plasma membrane
3. Theory of natural selection
4. Inheritance of acquired characteristics
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

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91. Which of the following transport processes does NOT require a carrier protein?
(A) Active transport
(B) Facilitated diffusion
(C) Simple diffusion
(D) Sodium-potassium pump

92. The function of the chloroplast is to convert light energy into chemical energy. This process is called:
(A) Photosynthesis
(B) Respiration
(C) Fermentation
(D) Transpiration

93. The packaging of DNA into a compact structure is essential because:
(A) It allows the DNA to be easily translated

(D) The rate of passive osmosis across the plasma membrane.

35. Arrange the following stages of mitosis in the correct chronological order:
1. Anaphase
2. Metaphase
3. Prophase
4. Telophase

Choose the correct option:
(A) 3, 2, 1, 4
(B) 2, 3, 1, 4
(C) 1, 2, 3, 4
(D) 3, 1, 2, 4

36. Crossing over, the exchange of genetic material between homologous chromosomes, occurs during which phase of meiosis?
(A) Metaphase II
(B) Anaphase I
(C) Telophase II
(D) Prophase I

37. The tendency for genes located close together on the same chromosome to be inherited together is known as:
(A) Independent assortment
(B) Polygenic inheritance
(C) Genetic linkage
(D) Aneuploidy

38. The cis-trans test of recombination is used to determine:
(A) The specific number of chromosomes in a eukaryotic cell.
(B) Whether two mutations are in the same gene or different genes.
(C) The overall rate of DNA replication within the nucleus.
(D) The electrical potential of a membrane during ion transport.

39. The non-coding sequences within a eukaryotic gene that are transcribed but removed before translation are called:
(A) Exons
(B) Promoters
(C) Operons
(D) Introns

40. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Chromosomal deletions can lead to genetic disorders.
Reason (R): Deletion involves the loss of a segment of a chromosome, which can result in the loss of one or more genes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

41. A chromosomal alteration where a segment is detached, reversed 180 degrees, and reattached is called:
(A) Duplication
(B) Translocation
(C) Inversion
(D) Deletion

42. Aneuploidy refers to a numerical change in chromosomes involving:
(A) The loss or gain of one or a few individual chromosomes.
(B) The addition of one or more complete sets of chromosomes.
(C) The exchange of segments between non-homologous chromosomes.
(D) The doubling of a small segment within a single chromosome.

43. Polyploidy, the condition of having more than two complete sets of chromosomes, is:
(A) Always lethal in all biological organisms.
(B) A type of structural change in a single chromosome.
(C) The result of a failure in DNA replication cycles.
(D) Common in plants and can lead to new species formation.

44. The presence of DNA in mitochondria and plastids constitutes the:
(A) Nuclear genome
(B) Extra-nuclear genome
(C) Interrupted gene
(D) Repetitive DNA

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cells, while active transport is animal.

103. Which organelle is often referred to as the "powerhouse" of the cell?
(A) Nucleus
(B) Ribosome
(C) Mitochondrion
(D) Golgi complex

104. The nucleolus, located within the nucleus, is the primary site for:
(A) Synthesis of ribosomal RNA and assembly of ribosomes.
(B) DNA replication throughout the entire eukaryotic genome.
(C) Chromosome condensation during the start of prophase.
(D) Processing of messenger RNA before it leaves the nucleus.

105. Which of the following best describes the structural organization of genes?
(A) Operons are a common feature of eukaryotic gene organization and regulation.
(B) Genes within an operon are never transcribed together as a single unit.
(C) Introns and exons are found within standard bacterial operon structures.
(D) Operons are co-transcribed; eukaryotic genes have introns.

106. The two sister chromatids of a replicated chromosome are held together at a specific region called the:
(A) Telomere
(B) Centromere
(C) Kinetochore
(D) Origin of replication

107. Which of the following is an example of a chromosomal duplication?
(A) A segment of chromosome 5 is moved to chromosome 12.
(B) A cell has three copies of chromosome 21 in its genome.
(C) A segment of a chromosome is lost during DNA replication.
(D) A segment is present in two copies instead of one copy.

108. The function of plastid DNA is most similar to that of mitochondrial DNA in that it:
(A) Codes for proteins involved in photosynthesis functions.
(B) Is inherited from both parents equally in sexual reproduction.
(C) Is a linear molecule, like nuclear chromosomes in the cell.
(D) Is not transcribed or translated into any functional products.

109. What is the phenotypic ratio expected from a dihybrid cross involving two independently assorting genes, where both are heterozygous (e.g., RrYy x RrYy)?
(A) 3:1
(B) 1:2:1
(C) 9:3:3:1
(D) 1:1:1:1

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110. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The spontaneity of mutation is a fundamental concept in evolution.
Reason (R): Mutations occur as a direct, adaptive response to environmental pressures, ensuring an organism's survival.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. Ion channels facilitate the movement of ions across a membrane by:
(A) Pumping ions against their gradient using energy from ATP.
(B) Binding to the ion and physically carrying it across the bilayer.
(C) Fusing with the membrane to create a temporary cytoplasmic pore.
(D) Providing a hydrophilic pathway through the membrane.

112. A cell that is highly active in synthesizing steroid hormones would be expected to have an extensive:
(A) Rough Endoplasmic Reticulum
(B) Smooth Endoplasmic Reticulum

(C) Golgi apparatus
(D) Lysosomal network

113. A karyotype is typically prepared from cells arrested in which phase of the cell cycle?
(A) Interphase
(B) Prophase
(C) Metaphase
(D) Telophase

114. Highly repetitive DNA sequences, such as satellite DNA, are often found in which chromosomal regions?
(A) Within the coding sequences of protein-encoding genes.
(B) In euchromatic regions of the chromosome structure.
(C) Only on the Y chromosome in the male genome.
(D) In centromeric and telomeric heterochromatin.

115. Match the following phases of meiosis in List I with their key events in List II and select the correct option.
List I: (Meiotic Phase)
P. Prophase I
Q. Metaphase I
R. Anaphase I
S. Anaphase II
List II: (Key Event)
1. Separation of sister chromatids
2. Separation of homologous chromosomes
3. Pairing of homologous chromosomes and crossing over
4. Alignment of homologous pairs at the equatorial plate
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-3, R-1, S-2

116. Which statement about gene expression is correct?
(A) All genes in a cell are expressed at all times in every tissue.
(B) Information from a gene is used to make a functional product.
(C) Gene expression involves only the process of DNA transcription.
(D) The final product of gene expression is always a functional protein.

117. An inversion that includes the centromere is known as a:
(A) Paracentric inversion
(B) Pericentric inversion
(C) Tandem duplication
(D) Reciprocal translocation

118. Which of the following is NOT a feature of plasmids?
(A) They replicate independently of the host chromosome.
(B) They are typically small and circular in their DNA structure.
(C) They are essential for the normal survival of the bacterium.
(D) They can carry genes for specialized antibiotic resistance.

119. A cross between a red-flowered plant and a white-flowered plant produces all pink-flowered offspring. This is an example of:
(A) Polygenic inheritance
(B) Codominance
(C) Incomplete dominance
(D) Complete dominance

120. Darwin's observation that finches on the Galapagos Islands had beaks of different shapes was evidence for:
(A) The inheritance of acquired characteristics in evolutionary history.
(B) Adaptation to different food sources via natural selection.
(C) The absolute stability of species over long periods of time.
(D) The spontaneity of mutation in the genetic code of finches.

121. The main difference between osmosis and diffusion is that:
(A) Osmosis requires energy, while diffusion does not require any.
(B) Osmosis is the movement of any substance, while diffusion is water.
(C) Osmosis is water movement across a semipermeable membrane.
(D) Diffusion only occurs in liquids, while osmosis occurs in gases.

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122. Which statement incorrectly describes the function of a cell organelle?
(A) Mitochondria are involved in cellular respiration.
(B) The vacuole in a plant cell stores water and maintains turgor.
(C) Ribosomes are responsible for detoxifying poisons.
(D) Lysosomes contain hydrolytic enzymes for digestion.

123. The 'beads on a string' appearance of chromatin under an electron microscope represents:
(A) The 30 nm chromatin fiber in the eukaryotic nucleus.
(B) Fully condensed mitotic chromosomes during metaphase.
(C) Nucleosomes, where DNA wraps around histone octamers.
(D) The structure of an operon in a bacterial genome.

124. Meiosis II is similar to mitosis in that:
(A) Homologous chromosomes are separated.
(B) The chromosome number is reduced by half.
(C) DNA replication precedes the division.
(D) Sister chromatids are separated.

125. Consider the following statements about Charles Darwin's contributions:
1. He proposed natural selection as the mechanism of evolution.
2. He explained the genetic basis of variation and inheritance through his work on pea plants.
3. He wrote "On the Origin of Species".
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

126. A protein pump that transports two different substances in the same direction across a membrane is called a(n):
(A) Symporter
(B) Uniporter
(C) Antiporter
(D) Ion channel

127. Which of the following is the most appropriate description of a peroxisome's function?
(A) It modifies, sorts, and packages proteins and lipids for secretion or delivery to other organelles.
(B) It contains its own DNA and is responsible for synthesizing ATP through oxidative phosphorylation.
(C) It contains oxidative enzymes that produce and break down hydrogen peroxide.
(D) It synthesizes proteins based on an mRNA template.

128. The concept of "interrupted gene" refers to the presence of introns and exons. What is the significance of exons?
(A) They are coding sequences joined to form mature mRNA.
(B) They are non-coding sequences that are removed during RNA processing.
(C) They regulate the rate of transcription in the eukaryotic nucleus.
(D) They are binding sites for transposons in the genomic DNA.

129. If nondisjunction (failure of chromosomes to separate) occurs during Meiosis I, what will be the chromosome number in the four resulting gametes?
(A) All four will be normal (n).
(B) Two will be normal (n), one will be n+1, and one will be n-1.
(C) Two will be n+1, and two will be n-1.
(D) All four will be diploid (2n).

130. Arrange the following levels of DNA packaging in eukaryotes from the least compact to the most compact:
1. 30 nm fiber
2. Metaphase chromosome
3. Nucleosome ('beads on a string')
4. Looped domains
Choose the correct option:
(A) 1, 3, 4, 2
(B) 3, 1, 2, 4
(C) 3, 1, 4, 2
(D) 1, 4, 3, 2

131. Which of the following statements about membrane proteins is correct?
(A) Peripheral membrane proteins are

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permanently embedded within the lipid bilayer.
(B) Integral membrane proteins are loosely bound to the surface of the membrane.
(C) All membrane proteins are fixed in place and do not move in the bilayer.
(D) Membrane proteins function as channels, receptors, and enzymes.

132. The primary role of the large central vacuole in a mature plant cell is to:
(A) Carry out complex photosynthesis.
(B) Maintain turgor pressure against the wall.
(C) Synthesize essential cellular proteins.
(D) Replicate genetic DNA information.

133. A chromosome with its centromere located very close to one end, resulting in one very long arm and one very short arm, is termed:
(A) Metacentric
(B) Submetacentric
(C) Acrocentric
(D) Telocentric

134. "Chromosome walking" is a method used in molecular biology for:
(A) Identifying genes by moving along a chromosome from a known marker.
(B) Observing the movement of chromosomes during anaphase of mitosis.
(C) Counting the total number of chromosomes in a eukaryotic cell nucleus.
(D) Staining chromosomes to reveal specific banding patterns for identification.

135. If a gene is located on mitochondrial DNA, how is it typically inherited in humans?
(A) It is passed from father to all offspring.
(B) It is passed from mother to all offspring.
(C) It follows a standard 3:1 Mendelian ratio.
(D) It is passed from father to son only.

136. The concept of "struggle for fitness" in an evolutionary context refers to the idea that:
(A) Organisms physically fight each other for survival in the wild.
(B) Not all born individuals will survive and reproduce.
(C) Organisms consciously try to improve their traits for the environment.
(D) Evolution is a random process with no specific biological direction.

137. Which of the following is a key element of the "evolutionary synthesis"?
(A) The total rejection of natural selection as a mechanism.
(B) Incorporating population genetics into Darwinian theory.
(C) The idea that acquired traits are inherited by offspring.
(D) The belief in a fixed and unchanging natural world.

138. The electrical potential across the plasma membrane of a non-excited cell is called the:
(A) Action potential
(B) Graded potential
(C) Resting membrane potential
(D) Equilibrium potential

139. A cell that is actively secreting a large amount of protein, such as a plasma cell secreting antibodies, would have a prominent:
(A) Smooth Endoplasmic Reticulum
(B) Peroxisome
(C) Rough ER and Golgi apparatus
(D) Central Vacuole

140. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Linkage is an exception to Mendel's Law of Independent Assortment.
Reason (R): Genes located close together on the same chromosome tend to be inherited together and do not assort independently.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

141. The function of the cell wall in fungi is structurally and chemically different from that of plants. Fungal cell walls are primarily composed of:
(A) Peptidoglycan
(B) Cellulose
(C) Chitin
(D) Hyaluronic acid

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142. Consider a scenario where a marine fish is placed in fresh water. What is the most likely osmotic consequence?
(A) The fish's cells will gain water and swell or lyse.
(B) The fish's cells will lose water and shrink significantly.
(C) There will be no net movement of water in this case.
(D) The fish will actively pump water out of its cells.

143. Which of the following organelles has a double membrane?
(A) Lysosome
(B) Peroxisome
(C) Endoplasmic Reticulum
(D) Chloroplast

144. What is the primary function of telomeres, the structures at the ends of eukaryotic chromosomes?
(A) To initiate DNA replication in the nucleus.
(B) To serve as attachment points for spindle fibers.
(C) To protect ends from degradation and fusion.
(D) To regulate the expression of genes in the middle.

145. Match the following terms related to gene structure in List I with their definitions in List II and select the correct option.
List I: (Term)
P. Exon
Q. Intron
R. Promoter
S. Enhancer
List II: (Definition)
1. A DNA sequence that increases the level of transcription of a gene; may be located far from the gene.
2. A non-coding segment of a gene that is removed from the transcript.
3. A coding segment of a gene that is part of the mature mRNA.
4. A DNA sequence where RNA polymerase binds to initiate transcription.
(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-2, R-3, S-1

146. A "frameshift" mutation is most likely caused by which type of chromosomal change?
(A) Nucleotide deletion/insertion not divisible by three.
(B) A pericentric inversion of a chromosomal segment.
(C) A balanced reciprocal translocation between chromosomes.
(D) The formation of a polyploid cell in the organism.

147. When a single gene has multiple effects on the phenotype of an organism, this phenomenon is known as:
(A) Pleiotropy
(B) Epistasis
(C) Polygenic inheritance
(D) Incomplete dominance

148. The concept of "spontaneity of mutations" implies that:
(A) Mutations are always beneficial to the organism.
(B) Mutations occur randomly, without specific purpose.
(C) The environment causes specific, directed mutations to occur.
(D) The rate of mutation is constant for all genes in all species.

149. The movement of ions through an ion channel is an example of:
(A) Active transport
(B) Simple diffusion
(C) Facilitated diffusion
(D) Endocytosis

150. All of the following are functions of the Golgi complex EXCEPT:
(A) Modification of proteins and lipids
(B) Synthesis of ATP
(C) Formation of lysosomes
(D) Packaging of materials into vesicles

151. Which statement best describes the structure of chromatin?
(A) Complex of DNA and histones in eukaryotic nuclei.
(B) It is a complex of RNA and histone proteins.

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(C) It is a double helix of DNA only.
(D) It is the circular chromosome found in bacteria.

152. Crossing over is a significant event in meiosis because:
(A) It ensures the correct number of chromosomes in cells.
(B) It creates new allele combinations, increasing diversity.
(C) It is the sole mechanism for DNA repair processes.
(D) It holds sister chromatids together until Anaphase II.

153. A translocation in which a chromosome segment is transferred to a non-homologous chromosome is a form of:
(A) Numerical change in chromosome number.
(B) Structural change in a chromosome.
(C) Gene mutation.
(D) Aneuploidy.

154. A key difference between Lamarck's and Darwin's views on evolution is:
(A) Darwin believed in evolution, but Lamarck did not.
(B) Lamarck focused on individuals; Darwin on populations.
(C) Lamarck believed in common descent, while Darwin did not.
(D) Darwin emphasized a struggle for existence, while Lamarck did not.

155. Consider the following statements about gene interactions:
1. In epistasis, one gene masks or modifies the phenotypic expression of another gene.
2. Codominance is when the heterozygote displays a phenotype intermediate between the two homozygous parents.
3. Polygenic inheritance involves a single gene controlling multiple traits.

Which of the statements given above is/are correct?
(A) 1 only
(B) 2 only
(C) 1 and 3 only
(D) 1, 2 and 3

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156. The mechanism of sorting and delivering proteins to the lysosome typically involves a specific chemical tag. This tag is:
(A) A poly-A tail
(B) A mannose-6-phosphate group
(C) A signal peptide at the N-terminus
(D) Ubiquitin

157. The smooth endoplasmic reticulum is involved in all of the following functions EXCEPT:
(A) Lipid and steroid synthesis
(B) Drug detoxification
(C) Calcium storage
(D) Protein synthesis for secretion

158. In which phase of the cell cycle are the chromosomes decondensed and located within a defined nucleus?
(A) Prophase
(B) Metaphase
(C) Anaphase
(D) Interphase

159. The exchange of genetic material between non-sister chromatids of homologous chromosomes is known as:
(A) Linkage
(B) Inversion
(C) Crossing over
(D) Nondisjunction

160. Turner Syndrome (XO) is an example of aneuploidy that results from:
(A) Nondisjunction of sex chromosomes during meiosis.
(B) A translocation between an autosome and a sex chromosome.
(C) The presence of an extra set of all chromosomes.
(D) A large deletion on the X chromosome.

161. Plasmids are important tools in molecular biology because they can be used as:
(A) A source of histones for DNA packaging.
(B) Vectors to clone and transfer genes.
(C) A way to create a karyotype.
(D) Markers for chromosome walking.

162. According to Mendel's Law of Dominance, if an organism has a heterozygous genotype (e.g., Rr), what phenotype will it express?

(A) The dominant phenotype.
(B) The recessive phenotype.
(C) An intermediate phenotype.
(D) A mix of both phenotypes.

163. The concept that heritable variation, overproduction of offspring, and differential survival lead to evolutionary change is a summary of:
(A) Lamarckism
(B) The Modern Synthesis
(C) Natural Selection
(D) Mendelian Genetics

164. The fluid mosaic model of the plasma membrane emphasizes that:
(A) Lipids and proteins move laterally within the membrane.
(B) The membrane is a rigid and static structure in cells.
(C) The membrane is composed solely of protein molecules.
(D) Water can pass freely through the hydrophobic lipid core.

165. The presence of cristae in mitochondria and thylakoids in chloroplasts serves a similar function, which is to:
(A) Store genetic material for the organelle.
(B) Maximize surface area for conversion reactions.
(C) Protect the organelle from osmotic stress.
(D) Synthesize lipids and steroids for membranes.

166. Euchromatin is characterized as:
(A) Tightly packed, transcriptionally inactive DNA.
(B) Loosely packed, transcriptionally active DNA.
(C) Highly repetitive satellite DNA sequences.
(D) DNA found only in the chromosomal centromere.

167. A cell in the G2 phase of the cell cycle contains:
(A) A single copy of its genome (unreplicated).
(B) Replicated chromosomes with two genome copies.
(C) Half the amount of DNA as a cell in G1.
(D) Chromosomes that are condensed and visible.

168. If the recombination frequency between two genes is 10%, what is the approximate map distance between them in centiMorgans (cM)?
(A) 1 cM
(B) 10 cM
(C) 50 cM
(D) 100 cM

169. What is the key difference between a deletion and an inversion?
(A) Deletion removes material; inversion reverses a segment.
(B) An inversion removes genetic material, while a deletion reverses a segment.
(C) A deletion involves two chromosomes, while an inversion involves one.
(D) An inversion always leads to a frameshift, while a deletion does not.

170. Which of the following is an example of an interaction of genes?
(A) Epistasis, where one gene masks another gene's alleles.
(B) A single gene determining flower color in plants.
(C) The segregation of alleles during meiotic division.
(D) The independent assortment of chromosomes in the cell.

171. The "evolutionary synthesis" integrated Darwin's theory with:
(A) Lamarck's ideas on inheritance of acquired traits.
(B) The specialized field of developmental biology.
(C) Mendelian genetics and population genetics.
(D) The fundamental principles of cell theory.

172. A key function of ion pumps like the Na^+/K^+ pump is to:
(A) Allow ions to diffuse down their concentration gradient.
(B) Maintain ion concentration gradients across the membrane.
(C) Synthesize ATP using an existing ionic gradient.
(D) Facilitate the movement of water across the membrane.

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(C) The specific location of a gene on a chromosome.
(D) The frequency of crossing over between two loci.

194. A human somatic cell that is triploid would have how many chromosomes?
(A) 23
(B) 46
(C) 92
(D) 69

195. A man with a genetic disorder caused by a mutation in his mitochondrial DNA will pass the disorder on to:
(A) All of his children.
(B) All of his daughters.
(C) All of his sons.
(D) None of his children.

196. The phenotype of an organism is determined by its genotype and:
(A) The environment.
(B) The number of chromosomes.
(C) The rate of cell division.
(D) Its evolutionary history.

197. The concept that populations have the potential for exponential growth, but are limited by resources, was an idea that Darwin adapted from:
(A) Thomas Malthus
(B) Gregor Mendel
(C) Jean-Baptiste Lamarck
(D) Charles Lyell

198. The mechanism of ion sorting in the cell ensures that specific ions are concentrated in particular compartments. This is primarily achieved through:
(A) Simple diffusion in the bilayer.
(B) Active transport via ion pumps.
(C) Passive osmosis of water.
(D) The process of pinocytosis.

199. A cell that engulfs a large particle, like a bacterium, does so through a process called:
(A) Phagocytosis
(B) Pinocytosis
(C) Receptor-mediated endocytosis
(D) Exocytosis

200. Arrange the following events of gene expression in a eukaryote in the correct chronological sequence:
1. Translation of mRNA into protein.
2. Transcription of DNA into pre-mRNA.
3. Processing of pre-mRNA (splicing, capping, tailing).
4. Export of mature mRNA from the nucleus.

Choose the correct option:
(A) 1, 2, 3, 4
(B) 2, 3, 4, 1
(C) 2, 1, 3, 4
(D) 3, 2, 4, 1

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201. Which of the following is NOT a function of the plasma membrane?
(A) Cell-cell communication
(B) Selective transport of substances
(C) Synthesis of genetic material
(D) Signal reception

202. The thylakoid, stroma, and granum are all components of which organelle?
(A) Chloroplast
(B) Mitochondrion
(C) Nucleus
(D) Golgi apparatus

203. A mutation that changes a single nucleotide in DNA but does not result in a change in the amino acid sequence of the protein is called a:
(A) Missense mutation
(B) Silent mutation
(C) Nonsense mutation
(D) Frameshift mutation

204. Cyclins are proteins that:
(A) Bind to and activate CDKs to control the cell cycle.
(B) Are enzymes that phosphorylate other proteins in the cell.
(C) Are structural components of the spindle fibers during mitosis.
(D) Replicate DNA sequences during the S phase of the cycle.

205. In a test cross, an individual with an unknown genotype for a dominant trait is crossed with:
(A) A heterozygous individual.
(B) A homozygous dominant individual.
(C) A homozygous recessive individual.

182. A cell is treated with a drug that inhibits ribosome function. Which process will be most immediately affected?
(A) Protein synthesis
(B) DNA replication
(C) ATP synthesis
(D) Osmosis

183. The complex of DNA and protein that makes up a eukaryotic chromosome is called:
(A) Cytoplasm
(B) A plasmid
(C) Chromatin
(D) A ribosome

184. The G0 phase of the cell cycle is:
(A) A stage of rapid cell division in tissues.
(B) The phase where DNA is replicated in cells.
(C) The final stage of mitotic division in cells.
(D) A non-dividing state with metabolic activity.

185. If two genes, A and B, are linked, a heterozygous individual (AB/ab) will produce which types of gametes in the highest proportion?
(A) AB and ab (parental types)
(B) Ab and aB (recombinant types)
(C) AB, ab, Ab, and aB in equal proportions
(D) Only AB gametes

186. The presence of mitochondrial DNA provides evidence for which theory?
(A) The theory of spontaneous generation of life.
(B) Endosymbiotic theory of organelle origin.
(C) Lamarck's theory of acquired characteristics.
(D) The theory of polygenic trait inheritance.

187. The emergence of evolutionary thought was characterized by a shift from a:
(A) static worldview to a dynamic one.
(B) dynamic worldview to a static one.
(C) genetic worldview to a geological one.
(D) chaotic worldview to an ordered one.

188. Which of the following is the best example of a "struggle for fitness"?
(A) A plant growing taller for sunlight than others.
(B) Two lions fighting over a specific territory.
(C) A bacterium acquiring a new plasmid molecule.
(D) A somatic cell undergoing mitosis in the body.

189. The sodium-potassium pump is an example of an antiporter because it:
(A) Pumps Na^+ out and K^+ into the eukaryotic cell.
(B) Pumps Na^+ and K^+ ions out of the cell simultaneously.
(C) Pumps Na^+ and K^+ ions into the cell simultaneously.
(D) Allows Na^+ and K^+ to diffuse freely across the bilayer.

190. Consider the following statements about chromosomes:
1. The karyotype represents the number and appearance of chromosomes in the nucleus.
2. Euchromatin is a highly condensed, transcriptionally inactive form of chromatin.
3. Transposons are mobile genetic elements that can change their position within a genome.

Which of the statements given above is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

191. A key distinction between the rough ER and the smooth ER is the presence of:
(A) A double membrane structure on the rough ER.
(B) DNA within the lumen of the rough ER system.
(C) Ribosomes on the surface of the rough ER.
(D) ATP synthase on the smooth ER membrane.

192. During which stage of meiosis do homologous chromosomes separate and move to opposite poles?
(A) Metaphase I
(B) Anaphase I
(C) Anaphase II
(D) Telophase I

193. The purpose of the cis-trans test is to establish:
(A) The total number of introns present in a gene.
(B) If mutations are alleles of the same gene.

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173. Lysosomes maintain an acidic internal pH. This is important because:
(A) Acidic environments are required for enzyme activity.
(B) It prevents the lysosome from bursting in the cytoplasm.
(C) It facilitates the synthesis of proteins in the lysosome.
(D) It neutralizes all toxins entering the eukaryotic cell.

174. A special type of chromosome found in the salivary glands of some insects, which is very large and shows distinct banding patterns, is the:
(A) Lampbrush chromosome
(B) B chromosome
(C) Telocentric chromosome
(D) Polytene chromosome

175. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Polyploidy is a significant evolutionary mechanism, particularly in plants.
Reason (R): The duplication of entire sets of chromosomes can lead to the creation of new species that are reproductively isolated from their diploid ancestors.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

176. Which statement accurately represents the Central Dogma of molecular biology, which underlies gene expression?
(A) Protein → RNA → DNA
(B) DNA → Protein → RNA
(C) RNA → DNA → Protein
(D) DNA → RNA → Protein

177. A condition where an organism has a chromosome number of 3n is an example of:
(A) Aneuploidy of individual chromosomes.
(B) Polyploidy (specifically, triploidy).
(C) Monosomy of a single chromosome.
(D) A reciprocal chromosomal translocation.

178. The inheritance pattern of traits determined by genes on plastid DNA would show:
(A) Maternal inheritance in most plant species.
(B) Standard Mendelian 3:1 phenotypic ratios.
(C) Equal contribution from both biological parents.
(D) X-linked inheritance patterns in the genome.

179. A characteristic feature of polygenic inheritance is that the traits:
(A) Show discontinuous variation in the population.
(B) Show continuous variation in the phenotype.
(C) Are determined by a single chromosomal gene.
(D) Are only influenced by environmental factors.

180. Match the following evolutionary concepts in List I with their descriptions in List II and select the correct option.
List I: (Concept)
P. Adaptation
Q. Variation
R. Fitness
S. Natural Selection
List II: (Description)
1. The differential survival and reproduction of individuals
2. A trait that improves an individual's ability to survive and reproduce
3. The differences among individuals in a population
4. The relative reproductive success of an individual
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-3, S-1

181. What is the primary role of cholesterol in animal cell plasma membranes?
(A) It acts as a primary energy source for metabolism.
(B) It modulates fluidity, preventing extremes in rigidity.
(C) It serves as a receptor for specific steroid hormones.
(D) It actively transports ions across the plasma membrane.

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(D) Another individual with the same unknown genotype.

206. A key feature of an operon is that:
(A) It contains a single large gene for protein.
(B) Co-regulated genes are transcribed as one mRNA.
(C) It is found only in complex eukaryotic species.
(D) It is always turned "on" in every cell type.

207. A pericentric inversion is a chromosomal rearrangement that:
(A) Does not include the centromere.
(B) Involves the exchange of segments with a non-homologous chromosome.
(C) Results in the loss of the centromere.
(D) Includes the centromere.

208. The evolutionary synthesis unified Darwin's theory with principles from:
(A) Genetics and population biology
(B) Physics and chemistry
(C) Geology and paleontology
(D) Embryology and anatomy

209. The movement of water into a cell via osmosis can cause a plant cell to become turgid, but an animal cell to lyse. This difference is due to the presence of:
(A) A plasma membrane in the plant cell.
(B) Mitochondria in the animal cell.
(C) A cell wall in the plant cell.
(D) A nucleus in the animal cell.

210. Which organelle is primarily responsible for the synthesis of lipids for the cell membrane?
(A) Ribosome
(B) Lysosome
(C) Smooth ER
(D) Rough ER

211. What is the role of histones in the cell nucleus?
(A) Enzymes that replicate DNA sequences.
(B) Regulatory proteins that control gene expression.
(C) Structural proteins that package and condense DNA.
(D) Channel proteins in the nuclear envelope structure.

212. The final result of meiosis is:
(A) Two diploid cells, identical to the parent cell line.
(B) Four diploid cells, different from the parent cell line.
(C) Four diverse haploid cells from one parent cell.
(D) Two haploid cells, identical to each other in genes.

213. A karyotype can be used to diagnose which of the following conditions?
(A) A point mutation in a single gene.
(B) A disorder caused by a faulty enzyme.
(C) An infection by a common virus.
(D) Aneuploidy, such as Trisomy 13.

214. Which statement about transposons is incorrect?
(A) They are stable DNA sequences that never change their location.
(B) They are also known as "jumping genes".
(C) Their movement can cause mutations by inserting into a gene.
(D) They are a source of genetic variation.

215. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Extra-nuclear inheritance does not follow Mendelian principles.
Reason (R): Genes located in mitochondria and chloroplasts are usually inherited from only one parent, typically the mother, and are not subject to segregation and independent assortment in the same way as nuclear genes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

216. A plant breeder wishes to create a new variety of rose with larger flowers and a stronger scent. These traits show continuous variation. This suggests the traits are likely controlled by:
(A) A single dominant gene.
(B) Codominant alleles.
(C) Polygenic inheritance.
(D) A lethal allele.

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217. The idea that giraffes acquired long necks by stretching to reach higher leaves and passed this trait to their offspring is an example of the mechanism proposed by:
(A) Charles Darwin
(B) Jean-Baptiste Lamarck
(C) Alfred Russel Wallace
(D) Gregor Mendel

218. In the context of the plasma membrane, what is the role of an ion channel?
(A) To allow specific ions to pass down their gradient.
(B) To provide energy for active transport of solutes.
(C) To synthesize new lipid molecules for the bilayer.
(D) To serve as rigid structural support for the cell.

219. The cis-face of the Golgi apparatus is oriented towards the:
(A) Plasma membrane
(B) Nucleus and Endoplasmic Reticulum
(C) Lysosome
(D) Mitochondrion

220. Match the following phases of the cell cycle in List I with their primary activities in List II and select the correct option.
List I: (Phase)
P. G1
Q. S
R. G2
S. M
List II: (Activity)
1. DNA replication
2. Mitosis and cytokinesis
3. Cell growth and preparation for DNA synthesis
4. Growth and preparation for cell division
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-1, R-3, S-2

221. Which type of chromosome has the centromere located exactly in the middle?
(A) Acrocentric
(B) Metacentric
(C) Telocentric
(D) Submetacentric

222. When does crossing over happen?
(A) During Prophase of mitosis.
(B) During Metaphase I of meiosis.
(C) During Prophase I of meiosis.
(D) During Anaphase II of meiosis.

223. What is the primary significance of introns in eukaryotic genes?
(A) They are directly translated into functional proteins for the cell.
(B) They are the primary sites for DNA replication to begin in chromosomes.
(C) They prevent the gene from being transcribed into mRNA by RNA polymerase.
(D) They allow for alternative splicing of one gene.

224. A Robertsonian translocation is a specific type of translocation that involves:
(A) Fusion of two acrocentric centromeres.
(B) The exchange of segments between two large chromosomes.
(C) The movement of a gene from a chromosome to a plasmid.
(D) The inversion of a segment that includes the telomere.

225. A key difference between unique and repetitive DNA is that:
(A) Unique DNA codes for proteins, while repetitive DNA never does in the genome.
(B) Unique DNA is present once; repetitive is multicopy.
(C) Repetitive DNA is only found in prokaryotes like bacteria and archaea.
(D) Unique DNA is significantly less stable than repetitive DNA in chromosomes.

226. If a cell has 2n=16 chromosomes, how many chromosomes will be present in each daughter cell after mitosis?
(A) 8
(B) 16
(C) 32
(D) 4

227. If a cell has 2n=16 chromosomes, how many chromosomes will be present in each gamete after meiosis?

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(A) 8
(B) 16
(C) 32
(D) 4

228. Which of the following organelles is NOT part of the endomembrane system?
(A) Endoplasmic Reticulum
(B) Golgi Apparatus
(C) Lysosome
(D) Mitochondrion

229. A key event in Anaphase of mitosis is:
(A) The condensation of chromosomes in the nucleus.
(B) Alignment of chromosomes at the metaphase plate.
(C) The separation of sister chromatids.
(D) Formation of the nuclear envelope in telophase.

230. Consider the following statements about membrane transport:
1. Active transport requires ATP and moves substances against their concentration gradient.
2. Simple diffusion allows small, nonpolar molecules to pass directly through the lipid bilayer.
3. Osmosis is the passive movement of water across a membrane.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

231. The primary function of a ribosome is to:
(A) Synthesize lipids
(B) Synthesize proteins
(C) Produce ATP
(D) Replicate DNA

232. In the lac operon, what molecule acts as the inducer?
(A) Glucose
(B) Lactose (or allolactose)
(C) The repressor protein
(D) RNA polymerase

233. A chromosomal deletion can be defined as:
(A) The addition of a segment of a chromosome.
(B) The reversal of a segment of a chromosome.
(C) The loss of a segment of a chromosome.
(D) The transfer of a chromosome segment to another chromosome.

234. In the context of evolution, "adaptation" refers to:
(A) A heritable trait that increases fitness.
(B) A change in an individual's behavior to survive.
(C) The process of getting used to a new climate.
(D) The random fluctuation of allele frequencies.

235. The concept that all living organisms have descended from a common ancestor is a central theme in:
(A) Mendelian genetics
(B) The cell theory
(C) The theory of evolution
(D) The study of the cell cycle

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236. Facilitated diffusion and active transport both:
(A) Require the use of specific transport proteins.
(B) Require energy in the form of ATP for movement.
(C) Move substances against a concentration gradient.
(D) Only transport water molecules across membranes.

237. The internal scaffolding of a cell, which provides shape, support, and a framework for movement, is called the:
(A) Cell wall
(B) Extracellular matrix
(C) Cytoskeleton
(D) Endoplasmic reticulum

238. If the two alleles for a particular gene are different, the individual is said to be:
(A) Heterozygous
(B) Homozygous
(C) Haploid
(D) Polyploid

239. The separation of homologous chromosomes occurs during:
(A) Mitosis

(B) Meiosis I
(C) Meiosis II
(D) Interphase

240. The theory of natural selection was independently co-discovered by Charles Darwin and:
(A) Gregor Mendel
(B) Jean-Baptiste Lamarck
(C) Alfred Russel Wallace
(D) Thomas Hunt Morgan

241. What is the function of the vacuole in protozoa like Paramecium?
(A) Photosynthesis for energy production.
(B) Maintaining water balance via osmoregulation.
(C) Protein synthesis in the cytoplasm.
(D) Genetic storage within the cell nucleus.

242. The main difference between a gene and an allele is that:
(A) An allele is a variant form of a gene.
(B) A gene is a variant form of an allele.
(C) Genes are on chromosomes, but alleles are not.
(D) Alleles are made of protein, but genes are made of DNA.

243. Klinefelter syndrome (XXY) is an example of:
(A) A structural chromosomal abnormality in humans.
(B) Aneuploidy of the sex chromosomes.
(C) Polyploidy of the entire genome in the cell.
(D) A point mutation in a single gene sequence.

244. The presence of plasmids that carry antibiotic resistance genes can be a major factor in:
(A) Failure of antibiotic therapies in medicine.
(B) The process of photosynthesis in plants.
(C) The packaging of eukaryotic DNA in nuclei.
(D) The formation of special chromosomes in cells.

245. Two parents are heterozygous for a recessive genetic disorder. What is the probability that their child will have the disorder?
(A) 25%
(B) 0%
(C) 50%
(D) 75%

246. Structural changes in chromosomes like deletion, duplication, translocation, and inversion are significant in evolution because they can:
(A) Alter arrangements and expression for selection.
(B) Only cause lethal diseases in all organisms.
(C) Prevent cell division from occurring in tissues.
(D) Ensure that offspring are identical to parents.

247. The "evolutionary synthesis" primarily unified which two fields?
(A) Darwinian evolution and Mendelian genetics.
(B) Lamarckian evolution and cell biology.
(C) Plate tectonics and paleontology.
(D) Biochemistry and developmental biology.

248. The role of the nuclear pore complex is to:
(A) Regulate molecule movement between nucleus and cytoplasm.
(B) Synthesize genomic DNA for the cell.
(C) Anchor chromosomes to the nuclear envelope membrane.
(D) Produce metabolic energy for the cell nucleus.

249. Which of the following is an example of a cell organelle that lacks a membrane?
(A) Mitochondrion
(B) Lysosome
(C) Ribosome
(D) Peroxisome

250. During the S phase of the cell cycle, a cell's DNA content changes from:
(A) 2C to 4C
(B) 4C to 2C
(C) 1C to 2C
(D) 2C to 1C

251. The phenomenon where genes on the same chromosome tend to be inherited together is called:
(A) Independent assortment
(B) Linkage
(C) Segregation
(D) Dominance

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252. A triploid organism (3n) would likely have problems during meiosis because:
(A) The DNA would not be able to replicate.
(B) Chromosomes cannot pair homologous sets properly.
(C) The spindle fibers would not form in cells.
(D) The nuclear envelope would not break down.

253. The genetic material of a mitochondrion is:
(A) A linear chromosome similar to nuclear DNA.
(B) A small, circular DNA molecule.
(C) A single-stranded RNA molecule in the matrix.
(D) A collection of various plasmids in the cell.

254. When a red cow (RR) is crossed with a white cow (WW) and the offspring are roan (RW), having both red and white hairs, this is an example of:
(A) Incomplete dominance in the offspring.
(B) Codominance of both alleles in the trait.
(C) Polygenic inheritance of multiple genes.
(D) Epistasis between two different genes.

255. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The plasma membrane is described as being selectively permeable.
Reason (R): The hydrophobic lipid bilayer and specific transport proteins allow the membrane to regulate which substances can pass through.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

256. Which of the following organelles is matched with an incorrect function?
(A) Nucleus: contains genetic material
(B) Mitochondrion: produces ATP
(C) Chloroplast: site of photosynthesis
(D) Lysosome: site of protein synthesis

257. What is the fundamental repeating unit of chromatin?
(A) The nucleosome
(B) The gene
(C) The centromere
(D) The telomere

258. A key regulatory point in the cell cycle occurs at the transition from G2 to M phase. This transition is triggered by the activation of:
(A) G1 cyclins in the nucleus.
(B) DNA polymerase in the cell.
(C) Maturation-promoting factor (MPF).
(D) Ribosomes in the cytoplasm.

259. A reciprocal translocation involves the:
(A) Loss of a piece of a chromosome.
(B) Exchange between non-homologous chromosomes.
(C) Reversal of a segment within one chromosome.
(D) Duplication of a segment on one chromosome.

260. Match the following genetic terms in List I with their definitions in List II and select the correct option.
List I: (Term)
P. Genotype
Q. Phenotype
R. Allele
S. Locus
List II: (Definition)
1. The observable characteristics of an organism
2. The specific location of a gene on a chromosome
3. An alternative form of a gene
4. The genetic makeup of an organism
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-3, S-4

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261. The work of which scientist was rediscovered at the turn of the 20th century, providing the basis for modern genetics and helping to complete the evolutionary synthesis?
(A) Charles Darwin
(B) Gregor Mendel
(C) Jean-Baptiste Lamarck
(D) Alfred Wegener

262. A plant cell placed in a hypotonic solution will become:

ANSWERS

1. (B) The outer layers including the plasma membrane, cell wall, and an outer membrane.
The cell envelope comprises the multilayered structure surrounding the cytoplasm of many bacteria and plants. It typically consists of the inner cytoplasmic membrane, a rigid cell wall providing structural integrity, and often an additional outer membrane. This collective complex serves as a protective barrier against environmental stress while maintaining the cell's internal environment and essential chemical balance for survival.

2. (A) It provides structural support and protection against osmotic stress.
Plant cell walls are primarily composed of cellulose, providing a rigid framework that supports the cell's shape and resists internal turgor pressure. This structure protects the organism from osmotic stress and physical damage. It acts as a primary defense barrier while allowing for controlled growth and facilitating communication through channels that connect adjacent cells within the complex plant tissue.

3. (C) A fluid bilayer of phospholipids with mobile associated proteins.
The fluid mosaic model describes the biological membrane as a dynamic arrangement of phospholipids and proteins. Phospholipids form a flexible bilayer where individual molecules can move laterally. Various proteins are embedded within or associated with this layer, shifting freely to perform vital functions such as transport, signaling, and enzymatic catalysis, which maintains the membrane's essential functional versatility and integrity.

4. (C) Statement I is true, but Statement II is false.
Phospholipids in the plasma membrane possess both hydrophilic heads and hydrophobic tails, ensuring the bilayer's structural stability in aqueous environments. While small nonpolar molecules can pass through easily, the hydrophobic core serves as a highly selective barrier. It naturally prevents the free diffusion of large, polar, or charged substances, which instead require specific transport proteins to enter the cell.

5. (A) Both A and R are true and R is the correct explanation of A.
Integral membrane proteins are permanently anchored within the phospholipid bilayer due to their unique chemical properties. These molecules contain hydrophobic amino acid sequences that interact with the fatty acid tails, alongside hydrophilic regions that face the watery cytoplasm or extracellular fluid. This specific orientation allows them to span the membrane entirely, facilitating critical tasks like molecule transport and signal transduction.

6. (B) Diffusion
Diffusion is a fundamental physical process characterized by the spontaneous movement of particles from areas of high concentration to areas of lower concentration. This passive transport mechanism continues until the substance is uniformly distributed throughout the available space. It does not require cellular energy expenditure, relying instead on the inherent kinetic energy and random motion of the individual atoms or molecules.

7. (D) The cell loses water and the membrane pulls from the cell wall.
Placing a plant cell in a hypertonic environment causes water to exit the cell through osmosis to balance solute concentrations. As the internal volume decreases, the central vacuole shrinks and the plasma membrane pulls away from the rigid cell wall. This process, known as plasmolysis, leads to a loss of turgor pressure, causing the plant tissue to wilt eventually.

8. (A) Open or close for ion diffusion in response to specific stimuli.
Gated ion channels are specialized transmembrane proteins that regulate the flow of specific ions across the biological membrane. They fluctuate between open and closed states in response to particular triggers, such as electrical voltage changes, mechanical stress, or chemical

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274. A cell that is terminally differentiated and will not divide again is likely in which phase?
(A) G1 phase
(B) S phase
(C) G0 phase
(D) M phase

275. In a two-point test cross, the percentage of recombinant offspring is used to estimate:
(A) The total number of genes in the organism's genome.
(B) The precise rate of mutation in the population.
(C) The distance between two genes on a chromosome.
(D) The ploidy level of the biological organism.

276. Which of the following is a structural change in a chromosome, as opposed to a numerical change?
(A) Trisomy
(B) Monosomy
(C) Inversion
(D) Polyploidy

277. The DNA found in a chloroplast is best described as:
(A) A single, circular molecule.
(B) Several linear chromosomes, each with a centromere.
(C) Identical to the nuclear DNA of the same cell.
(D) Interspersed with large amounts of histone proteins.

278. A father has blood type A (homozygous) and a mother has blood type B (homozygous). What is the only possible blood type for their children?
(A) Type AB
(B) Type A
(C) Type B
(D) Type O

279. The evolution of antibiotic resistance in bacteria is a direct and modern example of:
(A) Lamarckian inheritance
(B) Natural selection
(C) Genetic drift in large populations
(D) Artificial selection

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280. Arrange the following key events in the emergence of life and cellular structures chronologically:
1. Emergence of eukaryotic cells with membrane-bound organelles.
2. Synthesis of organic molecules from inorganic precursors.
3. Emergence of prokaryotic cells.
4. Formation of protocells (membrane-enclosed collections of molecules).

Choose the correct option:
(A) 2, 4, 3, 1
(B) 3, 2, 1, 4
(C) 1, 3, 4, 2
(D) 2, 3, 4, 1

281. The main structural difference between the cell wall of a plant and the cell wall of a bacterium is the presence of:
(A) Peptidoglycan in bacteria and cellulose in plants.
(B) Chitin in plants and cellulose in bacteria in the environment.
(C) Peptidoglycan in plants and cellulose in bacteria in the environment.
(D) Lignin in bacteria and peptidoglycan in plants in the environment.

282. The electrical potential across a membrane is a form of:
(A) Potential energy
(B) Kinetic energy
(C) Chemical energy
(D) Heat energy

283. The process by which the cell secretes materials by the fusion of a vesicle with the plasma membrane is called:
(A) Endocytosis
(B) Phagocytosis
(C) Pinocytosis
(D) Exocytosis

284. Which of the following best describes the structure of a eukaryotic chromosome in its most condensed state?
(A) A single strand of DNA in the nucleus.
(B) A circular loop of DNA in the cytoplasm.
(C) Two sister chromatids joined at a centromere.
(D) A loose network of chromatin in the

nucleus.

285. Inversions are chromosomal mutations that can suppress crossing over. This is because:
(A) The inverted segment is physically lost from the chromosome.
(B) Homologous chromosomes cannot pair in the inverted region.
(C) Inversions prevent DNA from replicating in the nucleus.
(D) The genes in the inverted segment become inactive in cells.

286. What is the main purpose of a test cross?
(A) To see if a dominant individual is homozygous or heterozygous.
(B) To determine the phenotype of an unknown individual in the population.
(C) To create a new, hybrid species through controlled breeding experiments.
(D) To measure the rate of mutation for a specific gene in the organism.

287. Which of the following is NOT a concept central to Darwin's theory of evolution?
(A) Heritable variation
(B) Struggle for existence
(C) Spontaneity of mutations
(D) Inheritance of acquired characteristics

288. A single-celled organism is moved from a saltwater environment to a freshwater environment. Its contractile vacuole would likely become:
(A) Less active
(B) More active
(C) Unchanged
(D) Disintegrated

289. The '9 + 2' arrangement of microtubules is characteristic of:
(A) Cilia and flagella in eukaryotic cells.
(B) Centrioles found in animal cell nuclei.
(C) The bacterial flagellum found in prokaryotes.
(D) The spindle fibers of mitosis in nuclei.

290. What defines a gene as "interrupted"?
(A) Coding sequence split by non-coding introns.
(B) It is frequently disrupted by transposons in the genome.
(C) Its transcription is often halted prematurely in the nucleus.
(D) It is located in a heterochromatic region of the chromosome.

291. If a diploid cell undergoes mitosis, the result is:
(A) Two haploid cells
(B) Four haploid cells
(C) Two diploid cells
(D) Four diploid cells

292. A human individual with 47 chromosomes has a condition known as:
(A) A delete
(B) An inversion
(C) Trisomy
(D) Triploidy

293. The observation that mitochondria have their own ribosomes and DNA supports the theory of:
(A) Spontaneous generation
(B) Endosymbiosis
(C) Gene flow
(D) Use and disuse

294. A pure-breeding tall plant (TT) is crossed with a pure-breeding short plant (tt). All F1 offspring are tall. This demonstrates:
(A) The law of segregation
(B) The principle of dominance
(C) The law of independent assortment
(D) Codominance

295. The combination of Darwin's theory of evolution by natural selection and Mendelian genetics is known as:
(A) The Lamarckian revival
(B) The evolutionary synthesis
(C) The theory of catastrophism
(D) The cell theory

296. Receptor-mediated endocytosis is more specific than phagocytosis or pinocytosis because it:
(A) Requires the use of energy from ATP in the cell.
(B) Involves the engulfment of large solid particles by the cell.
(C) Depends on binding molecules to membrane proteins.
(D) Only occurs in plant cells within the biological organism.

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297. A major function of the smooth ER in liver cells is:
(A) Synthesis of antibodies in the immune system.
(B) Detoxification of various drugs and poisons.
(C) Production of ATP for the cell's metabolic needs.
(D) Digestion of old organelles in the cytoplasm.

298. The ends of linear eukaryotic chromosomes are protected by structures called:
(A) Centromeres
(B) Kinetochores
(C) Telomeres
(D) Origins of replication

299. The physical exchange of segments between non-sister chromatids is called:
(A) Synapsis
(B) Cytokinesis
(C) Crossing over
(D) Disjunction

300. The concept that allele frequencies in a population can change over generations is a core definition of:
(A) The cell cycle
(B) Microevolution
(C) Homeostasis
(D) Ontogeny

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(A) Turgid
(B) Flaccid
(C) Plasmolyzed
(D) Lysed

263. The endomembrane system functions to:
(A) Produce ATP through cellular respiration.
(B) Control all cell division activities in the body.
(C) Synthesize, modify, and transport lipids and proteins.
(D) Provide a rigid structure to the biological cell.

264. What is the relationship between a gene and a chromosome?
(A) A chromosome is a segment of a gene.
(B) A gene is a DNA segment on a chromosome.
(C) Genes and chromosomes are unrelated structures in the cell.
(D) A gene is a condensed form of a chromosome in the nucleus.

265. What is the primary cause of genetic variation among individuals in a sexually reproducing population?
(A) Meiosis via crossing over and assortment.
(B) Mitosis in the somatic cell lines.
(C) The G0 phase of the cell cycle in cells.
(D) The structural integrity of the cell wall.

266. A mutation that results in an abnormal number of chromosomes, such as 45 or 47 in humans, is referred to as:
(A) An inversion
(B) A translocation
(C) Aneuploidy
(D) A point mutation

267. The discovery that DNA exists in mitochondria supported the idea that:
(A) Mitochondria were once free-living prokaryotes.
(B) Mitochondria are formed from the Golgi apparatus.
(C) All cellular DNA is located in the nucleus.
(D) Mitochondria are not essential for cell survival.

268. According to the Law of Segregation, alleles separate during:
(A) Gamete formation (meiosis)
(B) Mitosis
(C) Fertilization
(D) DNA replication

269. A trait that is influenced by multiple genes, such as skin color, is known as:
(A) A Mendelian trait
(B) A polygenic trait
(C) A codominant trait
(D) An X-linked trait

270. Consider the following statements about evolutionary concepts:
1. Natural selection acts on existing variation within a population.
2. Lamarck proposed that characteristics acquired during an organism's life could be inherited.
3. Fitness in an evolutionary sense refers to the relative reproductive success of an individual.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

271. An aquaporin is a specific type of:
(A) Ion pump
(B) Gated channel
(C) Channel protein for water
(D) Carrier protein for glucose

272. Which organelle plays a crucial role in autophagy, the process of recycling the cell's own old and damaged components?
(A) Golgi apparatus
(B) Lysosome
(C) Peroxisome
(D) Nucleus

273. The highly condensed state of a chromosome seen during mitosis is necessary for:
(A) Active transcription of genes in the nucleus.
(B) Accurate segregation to daughter cells.
(C) The initiation of DNA replication in S phase.
(D) The repair of DNA damage in the chromosome.

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ligands. This precise control is essential for maintaining cellular homeostasis and facilitating rapid communication, particularly within nervous and muscular tissues.

9. (C) It necessitates the constant movement of water across a membrane.
Active transport is a vital cellular mechanism that utilizes metabolic energy, usually derived from ATP, to move solutes against their natural concentration gradients. This process is highly selective and mediated by specific carrier proteins or pumps. While it regulates solute concentrations, it does not inherently require the continuous movement of water, which is primarily driven by osmotic pressure differences.

10. (A) P-4, Q-1, R-2, S-3
Membrane transport includes several distinct mechanisms. Simple diffusion involves nonpolar molecules moving down concentration gradients, while osmosis specifically refers to water movement across semipermeable membranes. Active transport necessitates ATP to move substances against gradients. Ion channels provide pathways for specific charged particles. Understanding these differences is crucial for grasping how cells maintain internal stability and manage nutrient uptake.

11. (D) The Golgi complex, where proteins are modified and packaged.
The Golgi complex acts as the central hub for modifying, sorting, and packaging proteins produced in the endoplasmic reticulum. It attaches specific molecular tags that determine the final destination of each protein, whether for secretion, incorporation into the plasma membrane, or delivery to lysosomes. This organized system ensures that cellular components receive the necessary functional molecules for proper physiological activity.

12. (B) Differential distribution of Na^+ and K^+ ions across the membrane.
Membrane potential is the electrical voltage difference across a cell membrane, created by the unequal distribution of ions. Specifically, the action of the sodium-potassium pump maintains high extracellular sodium and high intracellular potassium levels. Combined with selective permeability, this chemical gradient generates an electrical charge essential for transmitting nerve impulses and facilitating various cellular signaling processes across biological systems.

13. (C) Processing, packaging, and sorting of proteins and lipids.
The Golgi apparatus is a critical organelle within the endomembrane system, consisting of flattened membrane sacs called cisternae. Its primary role involves the biochemical modification of proteins and lipids received from the endoplasmic reticulum. By carefully sorting and packaging these molecules into specialized vesicles, the Golgi ensures they are accurately delivered to their correct intra- or extracellular functional sites.

14. (D) Maximize surface area for the transport chain and ATP synthesis.
Mitochondria contain an intricately folded inner membrane forming structures called cristae. This architectural adaptation significantly increases the available surface area for housing the electron transport chain and ATP synthase complexes. By expanding this internal workspace, the organelle maximizes its capacity for aerobic respiration and oxidative phosphorylation, thereby enhancing the cell's overall efficiency in generating chemical energy from nutrients.

15. (B) 1 and 2 only
Chloroplasts are specialized organelles in plants responsible for photosynthesis, capturing light energy to produce glucose. They possess their own circular DNA and ribosomes, supporting the endosymbiotic theory of their origin. While the light-dependent reactions occur in the thylakoid membranes, the light-independent Calvin cycle actually takes place within the stroma, which is the fluid-filled space surrounding the thylakoid system.

16. (B) Breaking down fatty acids and detoxifying harmful substances.
Peroxisomes are small, membrane-bound organelles containing oxidative enzymes. They play a vital role in lipid metabolism by breaking down long-chain fatty acids through beta-oxidation. Additionally, they facilitate the detoxification of harmful substances, such as alcohol, and manage hydrogen peroxide levels. By using the enzyme catalase, peroxisomes safely

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dedicated to DNA replication. G2 is the final period of growth and preparation specifically for mitosis, not exclusively for meiosis. The M phase encompasses chromosome segregation and cytokinesis, ensuring that each new cell receives a complete set of instructions.

34. (A) The activity of cyclin-dependent kinases (CDKs) and cyclins.
Regulation of the cell cycle is a tightly controlled process managed by internal signaling molecules. Cyclins are proteins whose concentrations fluctuate, while cyclin-dependent kinases are enzymes that become active only when bound to a specific cyclin. Together, they act as molecular checkpoints that monitor the cell's readiness to progress to the next phase, preventing errors in DNA replication and division.

35. (A) 3, 2, 1, 4
Mitosis follows a precise chronological order to ensure accurate chromosome distribution. It begins with prophase, where chromatin condenses into visible chromosomes. During metaphase, chromosomes align at the cell's equator. Anaphase follows as sister chromatids are pulled toward opposite poles. Finally, telophase involves the reformation of nuclear envelopes around the separated sets of chromosomes, followed by cytokinesis which completes the entire division process.

36. (D) Prophase I
Crossing over is the process by which homologous chromosomes exchange segments of genetic material during the first stage of meiosis. This occurs specifically during prophase I, when homologous pairs align closely in a process called synapsis. By shuffling maternal and paternal alleles, crossing over creates recombinant chromosomes with unique combinations, significantly increasing the genetic diversity within the resulting gametes of the organism.

37. (C) Genetic linkage
Genetic linkage refers to the tendency of genes that are physically located close to one another on the same chromosome to be inherited together during meiosis. Because they are close, they are less likely to be separated by crossing over events. This phenomenon serves as an exception to the law of independent assortment, which assumes that genes on different chromosomes segregate independently.

38. (B) Whether two mutations are in the same gene or different genes.
The cis-trans test, also known as the complementation test, is a functional assay used to determine if two independent mutations affect the same gene or different genes. If the mutations are in different genes, the organism will typically show a normal phenotype because each gene can provide the necessary function. If they are in the same gene, a mutant phenotype usually results.

39. (D) Introns
Eukaryotic genes are frequently composed of alternating coding and non-coding sequences. Introns are the non-coding segments that are transcribed into the primary RNA transcript but are subsequently removed during the process of RNA splicing. The remaining coding segments, called exons, are joined together to form the mature messenger RNA that is ultimately translated into a functional protein by the cell's ribosomes.

40. (A) Both A and R are true and R is the correct explanation of A.
Chromosomal deletions involve the physical loss of a segment of a chromosome, which can remove one or many vital genes. This loss of genetic material disrupts the balance of gene products required for normal development and physiology. Such imbalances often lead to severe physical and cognitive disorders, illustrating the importance of maintaining a complete and stable set of genetic instructions in cells.

41. (C) Inversion
An inversion is a structural chromosomal rearrangement that occurs when a segment of a chromosome breaks off, flips 180 degrees, and reattaches in its original position. Although no genetic material is lost or gained, the change in gene order can disrupt gene regulation or cause problems during meiosis, especially if it interferes with the proper pairing of homologous chromosomes in the organism.

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and studying evolutionary relationships between species.

25. (B) P-3, Q-4, R-2, S-1
Chromatin organization varies based on transcriptional activity; euchromatin is loosely packed and active, while heterochromatin is dense and silent. Genetic regulation involves units like operons in prokaryotes, which co-transcribe clusters of related genes. Genomes also contain transposons, mobile DNA segments capable of relocating. These elements collectively manage how genetic information is stored, expressed, and modified within an organism's complex genomic landscape.

26. (A) It allows alternative splicing for multiple protein production.
Interrupted genes contain coding exons and non-coding introns. During RNA processing, introns are removed, and exons are joined together. Alternative splicing allows different combinations of exons to be included in the final messenger RNA. This sophisticated mechanism enables a single gene to produce multiple distinct protein isoforms, significantly increasing the functional diversity of the proteome without requiring a larger number of genes.

27. (D) It contains a high density of active genes.
Heterochromatin is characterized by its highly condensed state and its location in transcriptionally silent regions, such as centromeres and telomeres. It replicates late during the S phase of the cell cycle and contains very few active genes. This dense packaging helps protect the structural integrity of the chromosome and plays a major role in regulating overall gene expression across the genome.

28. (B) Clone genes located near a known DNA marker sequence.
Chromosome walking is a molecular biology technique used to map or clone genes when their exact location is unknown but a nearby DNA marker is available. By sequentially identifying overlapping genomic clones, researchers can "walk" along the chromosome from the known marker to the gene of interest. This systematic approach was fundamental in early efforts to sequence complex eukaryotic genomes and genes.

29. (C) Move from one location in the genome to another.
Transposons are mobile genetic elements that can relocate within a genome, often referred to as jumping genes. This movement occurs through either a "cut-and-paste" or a "copy-and-paste" mechanism. By changing their position, transposons can disrupt existing genes, create new genetic variations, or influence the expression of nearby sequences, acting as a significant driver of genomic evolution and diversity.

30. (B) 1 and 2 only
Eukaryotic genomes are composed of different fractions based on sequence frequency. Unique sequence DNA generally contains protein-coding genes represented once per haploid set. In contrast, repetitive DNA consists of sequences found in multiple copies, ranging from moderately to highly repetitive. While some repetitive elements regulate genes, most protein-coding information is found in the unique fraction, highlighting the complexity of genome organization.

31. (A) Two genetically identical diploid cells.
Mitosis is a form of equational cell division that ensures genetic continuity between generations. During this process, a single diploid parent cell replicates its DNA and distributes it equally between two daughter cells. The resulting cells are genetically identical to each other and to the original cell, supporting growth, tissue repair, and asexual reproduction in various multicellular and unicellular eukaryotic organisms.

32. (B) Creates haploid gametes by halving the chromosome number.
Meiosis is a specialized type of cell division that reduces the chromosome number by half, resulting in the production of haploid gametes. This reduction is essential for sexual reproduction because it ensures that when fertilization occurs, the resulting zygote restores the correct diploid number. Meiosis also introduces genetic variation through crossing over and independent assortment, contributing to the diversity of life.

33. (B) G2 Phase – Preparation for meiosis.
The cell cycle consists of distinct phases that prepare the cell for division. G1 involves growth and protein synthesis, while the S phase is

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cellular respiration or in chloroplasts through the process of photosynthesis.

68. (D) Identifying chromosomes and detecting structural abnormalities.
Chromosome banding techniques, such as G-banding, involve staining condensed chromosomes to produce unique patterns of light and dark bands. These patterns are specific to each chromosome pair, allowing scientists to identify them accurately under a microscope. This process is invaluable for detecting structural changes like deletions, duplications, or translocations, which are often linked to specific genetic disorders or evolutionary changes.

69. (C) A DNA sequence where a repressor binds to block transcription.
In the context of a bacterial operon, the operator is a specific regulatory DNA sequence located between the promoter and the structural genes. It acts as a molecular switch. When a specific repressor protein binds to the operator, it physically blocks RNA polymerase from moving forward, thereby preventing the transcription of the genes. This allows the cell to conserve energy by producing enzymes only when needed.

70. (B) Eukaryotic genomes.
Eukaryotic genomes are significantly more complex than prokaryotic ones, characterized by the presence of both unique sequence DNA and various types of repetitive DNA. Unique sequences typically represent protein-coding genes, while repetitive sequences can include highly repetitive satellite DNA or moderately repetitive transposable elements. This organization reflects the sophisticated regulatory mechanisms and evolutionary history that define the complex architecture of eukaryotic genetic material.

71. (D) Homologous chromosomes pair and separate in meiosis I.
Mitosis and meiosis I differ fundamentally in their chromosomal behavior. Mitosis involves the separation of sister chromatids to produce genetically identical daughter cells. In contrast, meiosis I is characterized by the pairing of homologous chromosomes and their subsequent separation. This reductional division ensures that the resulting cells have half the original chromosome number, a necessary step for maintaining genetic stability across generations during sexual reproduction.

72. (A) Commit to DNA replication.
The G1/S checkpoint is a critical regulatory hurdle in the cell cycle. At this point, the cell assesses environmental conditions, nutrient availability, and DNA integrity. Passing this checkpoint signifies a commitment to enter the S phase and begin the energy-intensive process of DNA replication. If conditions are unfavorable or DNA is damaged, the cell may delay progression or enter a non-dividing G0 state.

73. (C) Close to 50%, behaving as unlinked.
Recombination frequency is a measure of how often crossing over occurs between two genes. When genes are located very far apart on the same chromosome, the probability of at least one crossover occurring between them is very high. Consequently, they appear to assort independently, resulting in a maximum recombination frequency of 50%. This makes them genetically behave as if they were on entirely different chromosomes.

74. (A) Two non-homologous chromosomes exchange segments.
A reciprocal translocation occurs when two different, non-homologous chromosomes break and exchange segments with each other. While the total amount of genetic material often remains the same, the rearranged positions of genes can disrupt their normal regulation. Furthermore, individuals carrying reciprocal translocations often face fertility issues because their chromosomes cannot pair and segregate correctly during the complex process of meiotic division.

75. (C) 2 and 3 only
Extranuclear inheritance involves genetic material found in mitochondria and chloroplasts rather than the nucleus. Unlike nuclear DNA, which follows Mendelian patterns of segregation and assortment, organelle DNA is typically inherited uniparentally. In many organisms, including humans and most plants, these organelles are passed down exclusively from the maternal parent via the cytoplasm of the egg cell during the fertilization process.

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42. (A) The loss or gain of one or a few individual chromosomes.
Aneuploidy is a type of numerical chromosomal abnormality characterized by an atypical number of chromosomes in a cell. This condition results from nondisjunction during cell division, leading to the gain of an extra chromosome, such as trisomy, or the loss of one, such as monosomy. Aneuploidy often results in significant developmental issues or genetic disorders due to an imbalance in gene dosage.

43. (D) Common in plants and can lead to new species formation.
Polyploidy is a condition where an organism possesses more than two complete sets of chromosomes, such as triploidy or tetraploidy. While often lethal in animals, it is very common and well-tolerated in the plant kingdom. Polyploidy can lead to increased cell size, vigor, and immediate reproductive isolation from diploid ancestors, making it a powerful mechanism for rapid speciation and evolutionary change.

44. (B) Extra-nuclear genome
While the majority of an organism's DNA is housed within the cell nucleus, small amounts of genetic material are also found in mitochondria and chloroplasts. This is known as the extra-nuclear genome. These organelles replicate independently and possess their own genes, which are essential for their specific metabolic functions. In most species, this genetic material is inherited uniparentally, typically from the mother.

45. (B) P-3, Q-1, R-4, S-2
Chromosomal abnormalities can be structural or numerical. Deletions involve the loss of segments, while duplications result in extra copies of genes. Translocations occur when a segment moves between non-homologous chromosomes. Aneuploidy refers to an abnormal total number of individual chromosomes. These changes disrupt the precise genetic balance required for normal function, often leading to varied phenotypic consequences or serious developmental disorders.

46. (D) Plasmids
Plasmids are small, circular DNA molecules that exist independently of the main bacterial chromosome. They replicate autonomously and often carry genes that provide selective advantages, such as antibiotic resistance or the ability to metabolize rare nutrients. Because they can be easily transferred between bacteria, plasmids play a major role in horizontal gene transfer and are essential tools in modern genetic engineering.

47. (A) The two alleles for a character separate during gamete formation.
Mendel's Law of Segregation posits that every individual possesses two alleles for each inherited trait. During the formation of gametes, these alleles separate so that each reproductive cell carries only one allele for every gene. This fundamental principle ensures that offspring receive one genetic contribution from each parent, allowing for the predictable inheritance patterns observed in classical genetics and breeding.

48. (B) Incomplete dominance
Incomplete dominance occurs when the phenotype of a heterozygous individual is a distinct blend or intermediate between the two homozygous phenotypes. Neither allele is completely dominant over the other. A classic example is the snapdragon flower, where crossing red and white parents results in pink offspring. This pattern reflects the reduced dosage of gene product produced by a single functional allele.

49. (B) A single trait is controlled by two or more genes.
Polygenic inheritance is a mode of inheritance where a single phenotypic trait is governed by the additive effects of two or more independent genes. This results in a continuous range of variation in the population rather than discrete categories. Common human examples include height, skin color, and eye color, where multiple loci contribute small, cumulative effects to the final expressed characteristic.

50. (B) 1 and 2 only
Lamarck's evolutionary theory proposed that organisms possess an innate drive toward greater complexity. His most famous concept

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was the inheritance of acquired characteristics, suggesting that physical changes occurring during an individual's lifetime due to environmental use or disuse could be passed to offspring. While natural selection was Darwin's later contribution, Lamarck's ideas were pioneering in suggesting that species change over time.

51. (C) Alfred Russel Wallace
Although Charles Darwin is the most famous figure associated with the theory of evolution, Alfred Russel Wallace independently arrived at nearly identical conclusions regarding natural selection. Both scientists observed how environmental pressures lead to the survival of individuals with favorable traits. Their joint presentation to the Linnean Society in 1858 marked a pivotal moment in the history of biological science and thought.

52. (D) The measure of an organism's reproductive success.
In the context of evolutionary biology, fitness refers to the relative ability of an individual to survive and pass its genes to the next generation. It is measured by an organism's total reproductive success compared to others in the population. Higher fitness indicates that an individual's traits are well-suited to the environment, increasing the frequency of those characteristics over successive generations.

53. (C) Darwin's theory of natural selection.
Darwin's theory of natural selection was influenced by the realization that populations produce more offspring than can survive on limited resources. This "struggle for existence" ensures that only individuals with the most advantageous variations survive and reproduce. Over time, this differential success leads to the gradual adaptation of the population to its environment, forming the basis of evolutionary change and speciation.

54. (B) Mutation
Mutation is the fundamental process that generates new genetic variation within a population. It involves random changes in the DNA sequence, which can create new alleles. While other processes like natural selection and gene flow redistribute or select from existing variation, only mutation provides the raw material necessary for the emergence of entirely new traits and long-term evolutionary progress in species.

55. (C) Statement I is true, but Statement II is false.
Natural selection acts on the phenotypes of individuals, determining which organisms survive and reproduce. However, the resulting evolutionary changes occur in the population as the frequency of favorable alleles increases over generations. Crucially, selection does not create new variations to suit an environment; it simply filters existing variations that were produced randomly through mutation and recombination during the reproductive process.

56. (A) The spontaneity of mutations.
The concept of the spontaneity of mutations highlights that genetic changes occur randomly and without regard to an organism's needs or the environmental conditions. Mutations are not a directed response to stress but rather accidental errors in DNA replication or damage. Natural selection then acts as a filter, preserving beneficial mutations while eliminating those that are harmful or neutral to survival.

57. (C) Integration of natural selection with Mendelian genetics.
The evolutionary synthesis, also known as the Modern Synthesis, was a major intellectual movement in the mid-20th century. it reconciled Darwin's theory of natural selection with Mendel's principles of inheritance and the new field of population genetics. This unified framework explained how gradual evolutionary change occurs through the selection of discrete genetic variations, providing a robust mathematical and biological foundation.

58. (A) An adaptation
An adaptation is a heritable trait or characteristic that has been refined by natural selection because it increases an organism's fitness in its specific environment. Adaptations can be structural, physiological, or behavioral. By improving the chances of survival and reproduction, these traits allow a population to become better matched to its ecological niche over many successive generations of evolutionary change.

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59. (D) Organisms inherit acquired characteristics.
Darwin's theory of natural selection is based on several key observations: variation exists within populations, resources are limited, and individuals with favorable traits are more likely to survive and reproduce. However, he did not include the inheritance of acquired characteristics, which was a central feature of Lamarck's earlier theory. Darwin focused instead on the selection of preexisting, heritable variations present in the population.

60. (A) Both A and R are true and R is the correct explanation of A.
The evolutionary synthesis was a critical milestone because it bridged the gap between macroevolution and microevolution. By integrating Mendelian genetics, it demonstrated that the discrete nature of inheritance is fully compatible with the gradual process of natural selection. This reconciliation provided a comprehensive explanation for how genetic variation is maintained and how it drives the evolutionary transformation of species over time.

61. (C) A thick peptidoglycan layer
The cell envelope of Gram-negative bacteria is characterized by a complex structure including an inner plasma membrane, a thin peptidoglycan layer, and a distinctive outer membrane. This contrasts with Gram-positive bacteria, which possess a much thicker peptidoglycan layer. The outer membrane and the periplasmic space in Gram-negative organisms provide an additional layer of protection and facilitate specific transport and metabolic processes.

62. (D) Hydrophobic core of the lipid bilayer.
The selective permeability of the plasma membrane is fundamentally due to the amphipathic nature of phospholipids. These molecules form a bilayer with a central hydrophobic core that acts as a formidable barrier to most polar and charged substances. Consequently, only small nonpolar molecules can pass through freely, while others must rely on specialized transport proteins to cross the biological membrane.

63. (A) Davson-Danielli Model
The Davson-Danielli model was an early attempt to describe membrane structure, proposing a lipid bilayer sandwiched between two continuous layers of globular proteins. While it correctly identified the bilayer foundation, it incorrectly suggested that proteins were fixed to the surface. This static view was later replaced by the fluid mosaic model, which accurately depicts proteins as mobile components embedded within the lipid layer.

64. (B) Active transport via an ion pump.
Moving substances from an area of low concentration to high concentration requires the cell to work against a natural gradient. This process necessitates the use of active transport mechanisms, which utilize metabolic energy in the form of ATP. Specialized transmembrane proteins, known as ion pumps, bind to the ions and move them across the membrane, maintaining vital chemical imbalances for cellular function.

65. (A) P-3, Q-1, R-4, S-2
Different cellular organelles perform specialized functions to maintain homeostasis. Ribosomes are the sites of protein synthesis, while the smooth endoplasmic reticulum handles lipid synthesis and detoxification. In plants, the central vacuole regulates turgor pressure and stores essential molecules. Peroxisomes contain enzymes like catalase to break down metabolic byproducts like hydrogen peroxide, ensuring that toxic substances do not damage the cell.

66. (A) Receiving vesicles from the ER and shipping them out.
The Golgi complex possesses a distinct structural and functional polarity. The "cis" face, or receiving side, is typically oriented toward the endoplasmic reticulum to accept transport vesicles. As materials pass through the cisternae, they are chemically modified and sorted. Finally, the "trans" face, or shipping side, packages the finalized products into new vesicles for delivery to their specific cellular destinations.

67. (C) It is the primary site of ATP synthesis.
The nucleus is the control center of the eukaryotic cell, housing the majority of its genetic material and managing activities like DNA replication and ribosome subunit assembly. It is enclosed by a protective double membrane. However, it is not the site of energy production. ATP synthesis occurs primarily in the mitochondria through

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84. (D) Ribosomes
The rough endoplasmic reticulum derives its name from the numerous ribosomes attached to its cytoplasmic surface, giving it a granular appearance under an electron microscope. These ribosomes are actively involved in synthesizing proteins that are either destined for secretion from the cell or for incorporation into various biological membranes. This close association allows for the immediate folding and modification of newly formed polypeptide chains.

85. (A) Both A and R are true and R is the correct explanation of A.
Eukaryotic genes are structured with coding regions called exons and non-coding regions called introns. During RNA processing, introns are excised and exons are joined. Alternative splicing allows for the inclusion of different combinations of exons in the final mRNA. This mechanism significantly expands a cell's protein-making capacity, allowing a single gene to produce multiple functional proteins with distinct roles in various tissues.

86. (B) DNA loops from the axis indicate high transcriptional activity.
Lampbrush chromosomes are exceptionally large chromosomes found in the oocytes of many animals. They are characterized by numerous lateral loops of DNA extending from a central protein axis. These loops represent regions of intense transcriptional activity, where DNA is being rapidly converted into RNA. This unique structural adaptation supports the massive requirement for gene products during the early stages of egg development and cellular growth.

87. (D) Euchromatin is transcriptionally active; heterochromatin is silent.
Chromatin exists in two primary functional states within the eukaryotic nucleus. Euchromatin is characterized by a more open, loosely packed structure, allowing access for the transcriptional machinery to express active genes. In contrast, heterochromatin is highly condensed and dense, which generally prevents gene expression. This spatial organization is a key mechanism for regulating which parts of the genome are active in different cell types.

88. (A) All chromosomes are properly attached to the spindle fibers.
The M checkpoint, also known as the spindle checkpoint, occurs during metaphase of mitosis. It ensures that all sister chromatids are correctly attached to the spindle microtubules and aligned at the cell's equator. This verification step is crucial for preventing errors in chromosome segregation, such as nondisjunction, which could result in daughter cells having an incorrect number of chromosomes, potentially leading to disease.

89. (C) Terminal deletion
A terminal deletion is a type of structural chromosomal abnormality that occurs when a single break happens near the end of a chromosome, resulting in the loss of the tip. Because this lost segment often contains important genes and the protective telomere, terminal deletions can have significant phenotypic effects and may lead to chromosomal instability or the fusion of broken chromosome ends.

90. (B) P-3, Q-4, R-1, S-2
Biological science has been shaped by major contributions from diverse researchers. Darwin proposed natural selection as the driver of evolution, while Lamarck emphasized the role of acquired traits. Mendel established the mathematical laws governing the inheritance of discrete genetic units. Singer and Nicolson revolutionized our understanding of cell structure by proposing the fluid mosaic model, describing the dynamic nature of the plasma membrane.

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91. (C) Simple diffusion
Simple diffusion is a passive transport process where small or nonpolar molecules move directly through the phospholipid bilayer from a higher to a lower concentration. Unlike facilitated diffusion or active transport, it does not require the assistance of specialized transmembrane carrier proteins or channels. It relies solely on the molecule's ability to dissolve in the hydrophobic lipid core of the membrane to cross the barrier.

92. (A) Photosynthesis
Photosynthesis is the fundamental biological process by which chloroplasts in plants and algae capture solar energy and convert it into

76. (B) On different chromosomes or very far apart on one.
Mendel's Law of Independent Assortment states that alleles for different traits are distributed to gametes independently. This principle applies most accurately to genes located on different chromosomes. It also holds true for genes that are very far apart on the same chromosome, as frequent recombination makes them appear unlinked. If genes are physically close, linkage occurs, and they tend to be inherited together as a unit.

77. (C) Polygenic inheritance.
Traits that exhibit continuous variation, where individuals show a smooth range of phenotypes rather than distinct categories, are typically governed by polygenic inheritance. In these cases, multiple independent genes contribute small, additive effects to the final expressed characteristic. Factors like height and skin color are classic examples, often further influenced by environmental variables, creating the complex phenotypic diversity observed within biological populations.

78. (D) Used parts become stronger, while unused parts deteriorate.
Lamarck's concept of "use and disuse" proposed that an organism's physical features change based on how much they are utilized during its lifetime. He argued that frequently used structures would strengthen and enlarge, while those neglected would gradually wither away. He believed these acquired changes were passed to offspring, providing a mechanism for species to adapt directly to their environments over many successive generations.

79. (A) Differential survival and reproduction.
Differential survival and reproduction is the fundamental engine of natural selection. In any population, individuals with heritable traits that provide a slight advantage in their specific environment are more likely to survive and successfully produce offspring. Over time, these advantageous alleles become more common in the population, leading to the gradual adaptation of the species and the emergence of complex biological features.

80. (A) 3, 1, 4, 2
Evolutionary thought progressed through key historical milestones. Lamarck first proposed his theory of acquired characteristics in the early 1800s. Darwin followed in 1859 with the publication of his evidence for natural selection. Meanwhile, Mendel conducted his landmark genetics experiments in the 1860s, though they remained obscure. Finally, in the mid-20th century, these fields were integrated into the Modern Synthesis, providing a unified evolutionary framework.

81. (B) Gram-positive bacterium
Gram-positive bacteria are distinguished by a cell envelope that includes a thick, rigid layer of peptidoglycan outside the plasma membrane. As prokaryotes, they lack a membrane-bound nucleus and other complex organelles. The thick cell wall provides significant structural support and determines the cell's shape while also protecting it from osmotic pressure changes in the external environment, which is vital for survival.

82. (A) The rapid opening and closing of voltage-gated ion channels.
Nerve cells transmit information through electrical signals called action potentials. These signals are generated by the precise, sequential opening and closing of voltage-gated sodium and potassium channels in the plasma membrane. This activity allows ions to flow rapidly across the membrane, causing temporary changes in electrical charge. This highly regulated process is fundamental to the functioning of the nervous system in all animals.

83. (C) Lysosomal proteins being secreted from the cell.
The cell's internal transport system meticulously sorts and delivers proteins to their required locations. Specific molecular tags, like mannose-6-phosphate, ensure that hydrolytic enzymes are directed to lysosomes rather than the secretory pathway. If this sorting mechanism fails, these enzymes might be secreted outside the cell or sent to incorrect organelles, potentially leading to tissue damage or the disruption of normal cellular metabolism.

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convert toxic hydrogen peroxide into water and oxygen, protecting the cell's integrity.

17. (B) Endoplasmic Reticulum – Protein synthesis and lipid metabolism
The endoplasmic reticulum is a multifunctional organelle network. The rough portion, studded with ribosomes, is the primary site for synthesizing and folding proteins destined for membranes or secretion. Conversely, the smooth portion focuses on lipid biosynthesis, steroid production, and calcium storage. This division of labor allows the cell to efficiently manage its diverse metabolic requirements and maintain structural component production.

18. (A) Digestion of macromolecules and old organelles via hydrolases.
Lysosomes are acidic, membrane-bound sacs containing a variety of hydrolytic enzymes capable of breaking down all types of biological polymers. They function as the cell's waste disposal and recycling center, digesting obsolete organelles, foreign pathogens, and macromolecules taken in through endocytosis. This degradation process prevents the accumulation of cellular debris and provides raw materials for the synthesis of new molecules.

19. (C) A double membrane perforated with nuclear pores.
The nucleus is shielded by a nuclear envelope, consisting of two concentric lipid bilayers. This barrier protects the genetic material from the metabolic activities of the cytoplasm. Specialized nuclear pore complexes span both membranes, meticulously regulating the transport of large molecules like RNA and proteins. This structure ensures that transcription and translation remain spatially separated, allowing for sophisticated gene regulation.

20. (A) Both A and R are true and R is the correct explanation of A.
Mitochondria and chloroplasts are termed semi-autonomous because they function somewhat independently of the cell's nucleus. They contain their own genetic material and the machinery necessary for protein synthesis, including ribosomes. While they still rely on nuclear genes for many components, their ability to replicate and produce some of their own proteins reflects their ancestral history as independent, free-living prokaryotes.

21. (C) A condensed molecule of DNA complexed with proteins.
A chromosome is an organized structure consisting of a very long, continuous piece of DNA that contains many genes and regulatory elements. In eukaryotes, this DNA is tightly coiled around proteins called histones, forming chromatin. This compact arrangement allows the massive amount of genetic information to fit within the nucleus and ensures its stable transmission during the process of cell division.

22. (B) Special types of chromosomes with unique structures and roles.
Polytene and lampbrush chromosomes represent specialized chromosomal forms optimized for high levels of gene expression. Polytene chromosomes result from repeated DNA replication without cell division, creating thick, banded structures. Lampbrush chromosomes feature prominent lateral loops of DNA, indicating active transcription during oogenesis in some animals. These unique structures allow researchers to visualize gene activity and study chromosomal architecture in detail.

23. (D) Histone proteins
DNA packaging is achieved through several hierarchical levels of condensation. The primary level involves wrapping the negatively charged DNA double helix around octamers of positively charged histone proteins. This interaction forms nucleosomes, which appear as beads on a string under an electron microscope. This fundamental structural unit helps reduce the overall length of DNA and facilitates more advanced levels of chromosomal organization.

24. (A) The organized profile of a person's chromosomes.
A karyotype is a standardized visual representation of an individual's complete set of chromosomes, typically captured during metaphase when they are most condensed. Scientists arrange them in pairs based on size, shape, and banding patterns. This clinical tool is essential for identifying numerical or structural chromosomal abnormalities, providing critical information for diagnosing genetic disorders

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chemical energy stored in glucose. This complex transformation involves light-dependent reactions in the thylakoid membranes and the Calvin cycle in the stroma. By utilizing water and carbon dioxide, photosynthesis provides the primary energy source for nearly all life on Earth and produces oxygen.

93. (C) It allows genomic DNA to fit inside the small nucleus.
The total length of DNA in a single human cell is approximately two meters, which must be contained within a nucleus only a few micrometers wide. Packaging DNA into a compact chromatin structure, using proteins like histones, is essential for fitting this massive amount of information into such a tiny space. This condensation also organizes the genome, protecting it from damage and facilitating accurate division.

94. (C) It helps to define the functional unit of a gene, or cistron.
The cis-trans test is a classic genetic experiment used to determine whether two recessive mutations are located within the same functional unit or in different units. It helped scientists define the "cistron," which is the modern equivalent of a gene. By observing whether the mutations complement each other to produce a normal phenotype, researchers can map the boundaries of functional genetic segments.

95. (C) Aneuploidy, specifically Trisomy 21.
Down syndrome is a common genetic condition caused by aneuploidy, where an individual has three copies of chromosome 21 instead of two. This chromosomal imbalance usually results from an error during meiosis called nondisjunction. The extra genetic material alters the course of development and causes the characteristic physical and cognitive features associated with the syndrome, demonstrating the importance of precise chromosome counts for health.

96. (C) Proteins for respiration and mitochondrial tRNAs and rRNAs.
Mitochondrial DNA is a small, circular genome that contains genes essential for the organelle's function. It primarily codes for critical proteins involved in the electron transport chain and aerobic respiration, as well as the specialized transfer RNAs and ribosomal RNAs needed for mitochondrial protein synthesis. Because mitochondria are inherited maternally, mutations in this DNA are passed through the maternal line to all offspring.

97. (A) 3:1
In a classic Mendelian monohybrid cross, the F1 generation is entirely heterozygous and expresses the dominant phenotype. When these F1 individuals are self-pollinated or crossed, the F2 generation typically exhibits a phenotypic ratio of 3:1. This means three-quarters of the offspring show the dominant trait, while one-quarter show the recessive trait, reflecting the predictable segregation of alleles during the process of gamete formation.

98. (C) Earth is old, and species have changed over time.
The development of evolutionary thought was deeply influenced by emerging evidence from geology and the fossil record. Observations showed that geological processes occur slowly over vast periods, suggesting Earth is much older than previously thought. Furthermore, the discovery of extinct organisms and transitional forms in fossil layers provided clear evidence that life on Earth is dynamic and that species undergo significant changes.

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99. (A) Suited organisms tend to survive and reproduce more successfully.
Natural selection is the primary mechanism of evolution, where individuals with heritable traits better suited to their environment are more likely to survive and reproduce. This differential success causes these advantageous traits to become more frequent in the population over time. It is a non-random process that results in the gradual adaptation of organisms to their specific ecological niches and environmental challenges.

100. (C) 2 and 3 only
The cell cycle is a highly active and regulated series of events. Interphase is not a resting stage; it is a period of intense metabolic activity, including cell growth and preparation for division. During the S phase, the cell's DNA is meticulously replicated. Checkpoints throughout the cycle ensure that each stage is completed correctly before moving

forward, maintaining the genetic integrity of the resulting cells.

101. (C) The cell wall
The bacterial cell wall is a rigid, external structure primarily composed of peptidoglycan. Its main function is to provide structural support and maintain the cell's specific shape, whether it be spherical, rod-like, or spiral. It also protects the bacterium from bursting due to internal osmotic pressure, serving as a critical barrier against various environmental stresses and maintaining the cell's overall integrity.

102. (A) Active transport requires energy input, while facilitated diffusion does not.
Active transport and facilitated diffusion are both mechanisms for moving substances across a membrane using specific proteins. However, facilitated diffusion is a passive process that moves molecules down their concentration gradient without energy. In contrast, active transport requires metabolic energy, usually ATP, to pump substances against their gradient, allowing cells to concentrate essential nutrients or maintain specific ionic balances regardless of external levels.

103. (C) Mitochondrion
Mitochondria are specialized double-membrane organelles responsible for aerobic cellular respiration. They convert the chemical energy found in nutrients, such as glucose, into adenosine triphosphate, the universal energy currency of the cell. This vital process provides the power necessary for nearly all cellular activities, leading to the common description of mitochondria as the energy-producing powerhouses of eukaryotic organisms and their various tissues.

104. (A) Synthesis of ribosomal RNA and assembly of ribosomes.
The nucleolus is a dense, non-membrane-bound structure located within the cell nucleus. It serves as the primary factory for the synthesis of ribosomal RNA and the initial assembly of ribosomal subunits. These subunits are then exported to the cytoplasm, where they combine to form functional ribosomes, which are essential for translating messenger RNA into the proteins required for various cellular functions and structures.

105. (D) Operons are co-transcribed; eukaryotic genes have introns.
Gene organization differs significantly between prokaryotes and eukaryotes. Prokaryotes often organize related genes into operons, which are transcribed together as a single messenger RNA molecule under one promoter. Eukaryotic genes are typically managed individually and are characterized by the presence of non-coding introns that must be removed through splicing. These different strategies allow for varied and complex levels of gene regulation and expression.

106. (B) Centromere
The centromere is a specialized region of a chromosome where the two identical sister chromatids are most tightly joined following DNA replication. It serves as the assembly site for the kinetochore, a protein complex that attaches to spindle fibers during cell division. This connection is vital for the accurate and organized segregation of chromosomes to daughter cells during both mitosis and the stages of meiosis.

107. (D) A segment is present in two copies instead of one copy.
A chromosomal duplication is a type of structural mutation where a segment of genetic material is repeated. This can occur due to errors during DNA replication or unequal crossing over during meiosis. While some duplications may be harmful, others provide a source of new genetic material that can evolve new functions over time, playing a significant role in gene family expansion and evolutionary innovation.

108. (A) Codes for proteins involved in photosynthesis functions.
Plastid DNA, such as that found in chloroplasts, is a small, circular genome that encodes several proteins essential for the organelle's specific role in photosynthesis. Similar to mitochondrial DNA, it is inherited independently of the nuclear genome and provides evidence for the endosymbiotic origin of these organelles. This genetic material allows the plastid to produce some of its own functional components and enzymes.

109. (C) 9:3:3:1
A dihybrid cross involves individuals that are heterozygous for two different, independently

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assorting genes. When these individuals are crossed, the resulting offspring typically exhibit four different phenotypic combinations in a 9:3:3:1 ratio. This predictable outcome demonstrates Mendel's Law of Independent Assortment, showing that the inheritance of one trait does not influence the inheritance of another when the genes are on different chromosomes.

110. (C) A is true but R is false.
Mutations are spontaneous and random events that occur without regard to an organism's environmental needs. They are not a directed adaptive response; most mutations are neutral or harmful. Evolution proceeds because natural selection acts as a filter, preserving the rare beneficial mutations that happen by chance. These favorable traits then increase in frequency because they happen to improve the individual's chances of reproductive success.

111. (D) Providing a hydrophilic pathway through the membrane.
Ion channels are specialized transmembrane proteins that create narrow, water-filled pores across the hydrophobic lipid bilayer. These pores provide a hydrophilic pathway that allows specific ions to diffuse rapidly down their electrochemical gradients. This mechanism is essential for processes that require fast changes in membrane potential, such as the conduction of electrical impulses in nerve and muscle cells throughout the biological organism.

112. (B) Smooth Endoplasmic Reticulum
The smooth endoplasmic reticulum is a versatile organelle primarily involved in the synthesis of lipids, including phospholipids and steroid hormones. It also plays a major role in detoxifying harmful chemicals and storing calcium ions. Cells specialized in producing large quantities of steroids, such as those in the adrenal glands or gonads, possess an extensive network of smooth ER to support these vital metabolic activities.

113. (C) Metaphase
A karyotype is typically prepared using cells that have been chemically arrested during metaphase of mitosis. At this stage, the chromosomes are at their maximum level of condensation and are most easily visible under a light microscope. This allows scientists to clearly distinguish each chromosome pair, facilitating the identification of numerical or structural abnormalities that may be present in the individual's genetic makeup.

114. (D) In centromeric and telomeric heterochromatin.
Highly repetitive DNA sequences, often called satellite DNA, are major components of constitutive heterochromatin. These sequences are primarily concentrated at the centromeres and telomeres of chromosomes. While they do not generally code for proteins, they play critical structural roles in maintaining chromosomal stability, assisting in the proper segregation of chromosomes during cell division, and protecting the ends of DNA strands from degradation.

115. (B) P-3, Q-4, R-2, S-1
Meiosis consists of two successive divisions that uniquely shuffle genetic material. Prophase I involves homologous pairing and crossing over, which generates diversity. During metaphase I, these pairs align at the cell's equator. Anaphase I separates the homologous chromosomes, reducing the total count. Finally, anaphase II resembles mitosis, as sister chromatids are pulled apart, resulting in four genetically distinct haploid gametes ready for fertilization.

116. (B) Information from a gene is used to make a functional product.
Gene expression is the multi-step process by which the information stored in a DNA sequence is used to synthesize functional products, such as proteins or non-coding RNA molecules. This process involves transcription of DNA into RNA and, for protein-coding genes, the translation of that RNA into a polypeptide. Gene expression is highly regulated, ensuring that the right products are made in the appropriate amounts.

117. (B) Pericentric inversion
An inversion is a chromosomal rearrangement where a segment is flipped 180 degrees. If the inverted region includes the centromere, it is called a pericentric inversion. If it does not include the centromere, it is termed paracentric. Pericentric inversions can change the relative lengths of the chromosome arms and are significant because they can lead to complex chromosomal imbalances during the process of meiosis.

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118. (C) They are essential for the normal survival of the bacterium.
Plasmids are small, extrachromosomal DNA loops found in many bacteria. They replicate independently of the main genome and are generally not required for basic survival under standard conditions. However, they frequently provide advantageous traits, such as antibiotic resistance or the ability to produce toxins. Because they can be shared between cells, they are major drivers of rapid bacterial evolution and adaptation in changing environments.

119. (C) Incomplete dominance
Incomplete dominance is a pattern of inheritance where the heterozygous phenotype is an intermediate blend of the two homozygous traits. In this case, neither the red nor the white allele is fully dominant, resulting in pink flowers. This occurs because the single functional allele in the heterozygote does not produce enough pigment to achieve the full red color, demonstrating how gene dosage affects expression.

120. (B) Adaptation to different food sources via natural selection.
Darwin's study of Galapagos finches revealed that their varied beak shapes were perfectly suited to the specific types of food available on different islands. This provided powerful evidence for adaptation through natural selection. Individuals with beaks best suited for local resources survived and reproduced more successfully. Over generations, these favorable traits became dominant, leading to the diversification of finch species from a common ancestor.

121. (C) Osmosis is water movement across a semipermeable membrane.
Diffusion is the general movement of any substance from a region of higher to lower concentration. Osmosis is a specific type of passive transport referring exclusively to the movement of water molecules across a selectively permeable membrane. Water moves toward the side with a higher solute concentration to achieve equilibrium. Both processes are driven by concentration gradients and do not require the expenditure of cellular energy.

122. (C) Ribosomes are responsible for detoxifying poisons.
Cellular organelles have highly specialized roles. Mitochondria produce energy, vacuoles maintain plant cell turgor, and lysosomes digest waste. However, ribosomes are exclusively involved in the translation of genetic information into proteins. Detoxification of harmful substances, such as drugs and poisons, is primarily the responsibility of the smooth endoplasmic reticulum, particularly in specialized tissues like the liver of multicellular biological organisms.

123. (C) Nucleosomes, where DNA wraps around histone octamers.
The "beads on a string" structure is the fundamental level of DNA organization in eukaryotes. The "beads" are nucleosomes, which consist of a segment of DNA wrapped twice around a core of eight histone proteins. This arrangement allows for the initial compaction of the long DNA molecule while still keeping it accessible for processes like transcription and replication, forming the basis for more condensed chromatin.

124. (D) Sister chromatids are separated.
Meiosis II and mitosis share structural similarities because both involve the separation of sister chromatids. During these divisions, the chromatids are pulled toward opposite poles of the cell by spindle fibers. However, the key difference is that meiosis II occurs in cells that are already haploid, having gone through the reductional division of meiosis I, while mitosis typically maintains the original chromosome count.

125. (B) 1 and 3 only
Charles Darwin is legendary for proposing natural selection as the primary mechanism for evolutionary change and for his seminal book, "On the Origin of Species." While he recognized that traits were inherited, he did not understand the underlying genetic mechanism. It was Gregor Mendel who, through his experiments with pea plants, discovered the particulate nature of inheritance and the laws governing how traits are passed.

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126. (A) Symporter
Transmembrane protein pumps that facilitate active transport can be classified by the direction of the substances they move. A symporter is a type of transporter that moves two different molecules or ions in the same direction across the plasma membrane. This often involves using the energy from the concentration gradient of one substance to drive the transport of another substance against its own gradient.

127. (C) It contains oxidative enzymes that produce and break down hydrogen peroxide.
Peroxisomes are metabolic organelles that contain specialized enzymes for performing oxidative reactions. They break down fatty acids and various toxic compounds, producing hydrogen peroxide as a byproduct. Because this byproduct is harmful, peroxisomes also contain catalase, an enzyme that immediately converts hydrogen peroxide into harmless water and oxygen. This dual role is essential for maintaining the chemical safety and metabolic efficiency of the cell.

128. (A) They are coding sequences joined to form mature mRNA.
In the structure of an interrupted gene, exons represent the essential segments that contain the actual coding information for a protein. During the process of transcription, the entire gene is copied, but the non-coding introns are then removed through splicing. The remaining exons are joined into a continuous sequence to form the mature messenger RNA, which then serves as the template for protein synthesis.

129. (C) Two will be n+1, and two will be n-1.
Nondisjunction is a failure of chromosomes to separate properly during cell division. If this occurs during meiosis I, a pair of homologous chromosomes fails to segregate. Consequently, all resulting gametes will have an abnormal chromosome number. Two gametes will receive an extra chromosome (n+1), while the other two will be missing one (n-1). This imbalance is a primary cause of conditions like Down syndrome.

130. (C) 3, 1, 4, 2
DNA packaging follows a hierarchical organization. It starts with nucleosomes, where DNA wraps around histones. These "beads" then coil into a 30 nm chromatin fiber. For further compaction, the fiber forms large looped domains attached to a protein scaffold. Finally, during cell division, these domains condense into the highly visible and compact metaphase chromosome, which is the most organized form of genetic material.

131. (D) Membrane proteins function as channels, receptors, and enzymes.
Membrane proteins are essential components that provide diverse functionality to the lipid bilayer. Integral proteins span the membrane, while peripheral proteins are loosely attached to the surface. These molecules act as selective channels or pumps for transport, as receptors for signaling molecules, and as enzymes to catalyze local reactions. Their mobility within the fluid lipid bilayer allows for dynamic cellular responses and environmental interactions.

132. (B) Maintain turgor pressure against the wall.
The large central vacuole is a defining feature of mature plant cells. By accumulating water and various solutes, it creates internal osmotic pressure, known as turgor pressure, which pushes against the rigid cell wall. This pressure provides structural support, keeping the plant upright and firm. The vacuole also serves as a storage site for nutrients, waste products, and pigments, contributing to overall cellular homeostasis.

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133. (C) Acrocentric
Chromosomes are classified based on the position of their centromere. An acrocentric chromosome has its centromere located very near one end, resulting in one remarkably long arm and one tiny, sometimes barely visible, short arm. This asymmetry is distinct from metacentric chromosomes, where the centromere is central, and telocentric chromosomes, where it is at the very tip, potentially affecting how the chromosome behaves during division.

134. (A) Identifying genes by moving along a chromosome from a known marker.
Chromosome walking is a systematic molecular technique used to find and clone a specific gene of interest. It begins with a known DNA sequence, or marker, located near the gene. By isolating overlapping genomic fragments, researchers can progressively move, or "walk," along the

it from damage and allowing it to fit into the small nuclear space. The degree of chromatin compaction also plays a critical role in regulating gene expression and DNA accessibility.

152. (B) It creates new allele combinations, increasing diversity.
Crossing over is a pivotal event during prophase I of meiosis, where homologous chromosomes exchange segments of genetic material. This process shuffles maternal and paternal alleles, resulting in recombinant chromosomes with unique genetic combinations. By increasing the variation within gametes, crossing over ensures that offspring are genetically distinct from their parents and each other, providing the raw material for natural selection and evolutionary adaptation.

153. (B) Structural change in a chromosome.
A translocation is a type of structural chromosomal abnormality where a segment of one chromosome breaks off and attaches to a different, non-homologous chromosome. This rearrangement can be reciprocal, where two chromosomes exchange pieces, or non-reciprocal. Although the total number of chromosomes might remain the same, the change in gene position can disrupt normal regulation and lead to various genetic disorders or reproductive challenges.

154. (B) Lamarck focused on individuals; Darwin on populations.
Lamarck's theory emphasized how individual organisms adapt by changing their own traits during their lifetime and passing those changes to their offspring. In contrast, Darwin's theory of natural selection focuses on populations. He proposed that evolutionary change occurs as the frequency of heritable, advantageous traits increases over generations because individuals with those traits are more likely to survive and successfully reproduce in their specific environment.

155. (A) 1 only
Gene interactions significantly influence inheritance patterns. In epistasis, the expression of one gene is masked or modified by another independent gene. In contrast, codominance occurs when both alleles in a heterozygote are fully expressed, like in AB blood types. Polygenic inheritance involves multiple genes contributing to a single trait, such as height. These complex relationships explain why many traits do not follow simple Mendelian inheritance ratios.

156. (B) A mannose-6-phosphate group
To ensure proper cellular function, proteins must be delivered to their correct destinations. Proteins destined for the lysosome are synthesized in the rough endoplasmic reticulum and then move to the Golgi complex. There, they receive a specific chemical tag called mannose-6-phosphate. This molecular address is recognized by specialized receptors that package the enzymes into vesicles specifically headed for the lysosome, preventing them from being misdirected.

157. (D) Protein synthesis for secretion
The smooth endoplasmic reticulum is a versatile organelle involved in lipid and steroid biosynthesis, detoxification of drugs and metabolic wastes, and the storage of calcium ions. Unlike the rough ER, it lacks ribosomes and therefore does not participate in protein synthesis. Secretory proteins are produced exclusively on the ribosomes of the rough ER before being processed and packaged for export from the cell.

158. (D) Interphase
Interphase is the longest period of the cell cycle, during which the cell grows, performs its normal metabolic functions, and replicates its DNA. During this stage, the chromosomes are in their decondensed, thread-like chromatin form and are contained within a clearly defined nuclear envelope. It is only when the cell enters mitosis that the chromatin condenses into the distinct, visible chromosomes typically seen in diagrams.

159. (C) Crossing over
Crossing over is a fundamental genetic process that occurs during prophase I of meiosis. It involves the physical exchange of corresponding segments between non-sister chromatids of homologous chromosome pairs. This process results in the recombination of alleles, creating new genetic combinations that did not exist in either parent. This reshuffling of genetic information is a primary source of variation in sexually reproducing species and populations.

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143. (D) Chloroplast
While many organelles are bounded by a single membrane, certain complex structures like the nucleus, mitochondria, and chloroplasts are enclosed by a double membrane. The chloroplast's dual-membrane system separates its internal metabolic processes, such as the light reactions and the Calvin cycle, from the rest of the cell. This structural complexity is a hallmark of organelles thought to have originated from ancestral endosymbiotic events.

144. (C) To protect ends from degradation and fusion.
Telomeres are repetitive DNA sequences located at the extreme ends of linear eukaryotic chromosomes. They act as protective caps that prevent the chromosome from unraveling or fusing with other chromosomes. Telomeres also solve the "end-replication problem" by ensuring that vital coding sequences are not lost during successive rounds of DNA replication. Their gradual shortening over time is closely linked to cellular aging and division limits.

145. (A) P-3, Q-2, R-4, S-1
Eukaryotic gene regulation involves complex structural elements. Promoters are sites where RNA polymerase initiates transcription. Enhancers are distant sequences that boost transcriptional levels. Within the gene itself, introns are non-coding segments that are spliced out, while exons are the coding regions that remain to form the final messenger RNA. This sophisticated organization allows for precise control over when and how much of a protein is produced.

146. (A) Nucleotide deletion/insertion not divisible by three.
A frameshift mutation occurs when nucleotides are added to or deleted from a DNA sequence in a number not divisible by three. Because ribosomes read mRNA in three-base codons, this shift alters the entire reading frame downstream of the mutation. This typically results in a completely different amino acid sequence and often produces a premature stop codon, leading to a non-functional or truncated protein.

147. (A) Pleiotropy
Pleiotropy is a genetic phenomenon where a single gene influences multiple, seemingly unrelated phenotypic traits. This often occurs because the gene's product is used in different biochemical pathways or various tissues throughout the body. For example, a mutation in a gene coding for a structural protein might affect both the skeletal system and the integrity of internal organs, demonstrating the interconnected nature of genetic pathways.

148. (B) Mutations occur randomly, without specific purpose.
The concept of spontaneous mutation emphasizes that genetic changes arise by chance due to errors in DNA replication or environmental damage, rather than as a directed response to an organism's needs. Mutations do not appear because they would be beneficial; instead, they provide the random raw material upon which natural selection acts, preserving the rare advantageous changes and eliminating the more common harmful ones.

149. (C) Facilitated diffusion
Ion channels are transmembrane proteins that provide a selective, hydrophilic pathway for specific ions to move across the hydrophobic lipid bilayer. This movement is a form of facilitated diffusion because it occurs passively, driven by the ion's electrochemical gradient, and does not require energy. Channels can be gated, opening only in response to specific electrical, mechanical, or chemical signals to regulate cellular activity.

150. (B) Synthesis of ATP
The Golgi complex is a vital organelle for modifying, sorting, and packaging proteins and lipids for transport. it is central to the formation of lysosomes and secretory vesicles. However, it does not participate in energy production. ATP synthesis is the specialized role of mitochondria through aerobic respiration or chloroplasts through photosynthesis, providing the necessary chemical power for the Golgi and other cellular functions.

151. (A) Complex of DNA and histones in eukaryotic nuclei.
Chromatin is the functional form of genetic material found within the eukaryotic nucleus. It consists of a long strand of DNA wrapped around alkaline proteins called histones. This complex serves to condense the DNA, protecting

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chromosome until the desired gene is reached. This method was crucial for mapping large genomes before the advent of high-throughput sequencing.

135. (B) It is passed from mother to all offspring.
In humans and most animals, mitochondrial DNA exhibits a maternal inheritance pattern. During fertilization, the sperm contributes only nuclear DNA, while the egg provides both nuclear DNA and the cytoplasm containing all the mitochondria. Consequently, all offspring, regardless of their sex, inherit their mitochondrial genome exclusively from their mother. This unique inheritance is used by scientists to trace maternal lineages and evolutionary history.

136. (B) Not all born individuals will survive and reproduce.
The concept of the "struggle for existence" or fitness recognizes that populations tend to produce more offspring than the environment can support. This leads to competition for limited resources such as food, water, and space. Only those individuals with traits best suited to their environment will successfully survive and reproduce. This differential success is the primary driver of natural selection and evolutionary change in populations.

137. (B) Incorporating population genetics into Darwinian theory.
The evolutionary synthesis transformed biological thought by merging Darwin's concept of natural selection with the mathematical principles of population genetics and Mendelian inheritance. It provided a clear mechanism for how small, beneficial genetic changes can accumulate in a population over time. This unified theory explained both microevolutionary shifts within species and the broader patterns of macroevolution and speciation observed in the fossil record.

138. (C) Resting membrane potential
The resting membrane potential is the steady electrical charge difference across the plasma membrane of a cell when it is not actively transmitting a signal. It is primarily established by the selective permeability of the membrane to specific ions and the activity of the sodium-potassium pump. This potential energy is essential for the function of excitable cells, such as neurons and muscle fibers, in all animals.

139. (C) Rough ER and Golgi apparatus
Cells dedicated to high-volume protein secretion possess an extensively developed endomembrane system. The rough endoplasmic reticulum, heavily studded with ribosomes, is the initial site for protein synthesis and folding. These proteins are then transported to the Golgi apparatus for final modification, sorting, and packaging into secretory vesicles. This coordinated pathway allows for the efficient production and delivery of molecules like antibodies or digestive enzymes.

140. (A) Both A and R are true and R is the correct explanation of A.
Genetic linkage occurs when genes are physically located close to each other on the same chromosome. Because they are near, they are likely to be inherited as a single unit during meiosis, rather than segregating independently. This phenomenon contradicts Mendel's Law of Independent Assortment, which only applies to genes on different chromosomes or those located far apart, where recombination can occur frequently.

141. (C) Chitin
Fungal cell walls provide essential structural support and protection against environmental stress. Unlike the cellulose-based walls of plants or the peptidoglycan-based walls of bacteria, fungal walls are primarily composed of chitin. Chitin is a strong, fibrous nitrogen-containing polysaccharide that also makes up the exoskeletons of arthropods. This distinct chemical composition is a key characteristic used to classify fungi as a separate kingdom of biological life.

142. (A) The fish's cells will gain water and swell or lyse.
Fresh water is hypotonic to the cells of a marine fish, meaning it has a lower solute concentration than the fish's internal environment. When placed in fresh water, osmosis will drive water into the fish's cells in an attempt to reach equilibrium. Without effective osmoregulation, this influx of water causes the cells to swell and potentially burst, leading to severe physiological distress or death.

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160. (A) Nondisjunction of sex chromosomes during meiosis.
Turner Syndrome is a chromosomal condition in humans where a female has only one functional X chromosome (XO) instead of the usual two. This is an example of aneuploidy, specifically monosomy. It typically results from nondisjunction, an error where sex chromosomes fail to separate correctly during the formation of gametes in a parent. This missing genetic material leads to various developmental and physiological characteristics.

161. (B) Vectors to clone and transfer genes.
Plasmids are essential tools in biotechnology because they are small, circular, and can replicate independently of the host's main chromosome. Scientists use them as vectors to insert foreign DNA into bacteria or other cells. By carrying specific genes, such as those for human insulin or antibiotic resistance, plasmids allow researchers to clone, study, and produce large quantities of useful proteins or genetically modified organisms.

162. (A) The dominant phenotype.
According to Mendel's Law of Dominance, when an individual has two different alleles for a single trait, only the dominant allele is expressed in the phenotype. The recessive allele remains hidden, although it is still present in the genotype and can be passed to future generations. The dominant trait masks the presence of the recessive trait, ensuring that the organism appears physically like a homozygous dominant individual.

163. (C) Natural Selection
Natural selection is the core mechanism of evolution proposed by Charles Darwin. It relies on three primary conditions: individuals within a population must vary in their traits, these traits must be heritable, and more offspring must be produced than can survive. Those with advantageous traits are more likely to survive and reproduce, leading to a gradual increase in the frequency of those favorable traits over time.

164. (A) Lipids and proteins move laterally within the membrane.
The fluid mosaic model describes the plasma membrane as a dynamic and flexible structure. The "fluid" part refers to the ability of individual phospholipid and protein molecules to move laterally within the bilayer. The "mosaic" part describes the diverse array of proteins, carbohydrates, and lipids embedded in the membrane. This mobility is essential for processes like cell signaling, transport, and the fusion of membrane vesicles.

165. (B) Maximize surface area for conversion reactions.
Both mitochondria and chloroplasts contain highly folded internal membranes, known as cristae and thylakoids, respectively. This structural adaptation serves a common purpose: to vastly increase the surface area available for critical biochemical reactions. By providing more space for the electron transport chain in mitochondria or the light-dependent reactions in chloroplasts, these folds maximize the efficiency of energy conversion processes like respiration and photosynthesis.

166. (B) Loosely packed, transcriptionally active DNA.
Euchromatin is a lightly packed form of chromatin that is enriched in genes. Its open structure allows RNA polymerase and other regulatory proteins to easily access the DNA sequence, facilitating active transcription. In most eukaryotic cells, the majority of the genome that is being utilized for protein synthesis exists as euchromatin, while silent or structural regions are maintained in a more condensed heterochromatic state.

167. (B) Replicated chromosomes with two genome copies.
The G2 phase is the period of the cell cycle that follows DNA replication in the S phase and precedes mitosis. Consequently, a cell in G2 contains twice the amount of DNA as a cell in the G1 phase. Each chromosome now consists of two identical sister chromatids joined at a centromere. This ensures that the cell has a complete and verified second copy of its entire genome before dividing.

168. (B) 10 cM
Map distance on a chromosome is measured in centiMorgans, where one centiMorgan represents a one percent chance that two genes will be separated by crossing over during meiosis. Therefore, if the recombination frequency between two genes is found to be ten percent, the approximate distance between them is ten

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centiMorgans. This linear relationship allows geneticists to create relative maps of gene locations based on breeding data.

169. (A) Deletion removes material; inversion reverses a segment.
Deletions and inversions are both structural chromosomal mutations, but they differ in their effect on genetic content. A deletion involves the actual loss of a chromosomal segment and its associated genes, often leading to severe health consequences. In contrast, an inversion reverses the orientation of a segment without losing any material. While less immediately catastrophic, inversions can still disrupt gene regulation and cause issues during chromosome pairing.

170. (A) Epistasis, where one gene masks another gene's alleles.
Gene interaction occurs when the expression of one gene is influenced by one or more other genes. Epistasis is a classic example, where the alleles of one gene mask or hide the phenotypic expression of alleles at a completely different locus. For instance, in some animals, one gene may determine the presence of pigment, while another determines the specific color, demonstrating how genes work together.

171. (C) Mendelian genetics and population genetics.
The evolutionary synthesis, developed in the mid-20th century, provided a unified framework for biology. It successfully integrated Darwin's theory of natural selection with the principles of Mendelian inheritance and the mathematical insights of population genetics. This synthesis explained how continuous evolutionary change can arise from the selection of discrete genetic units, establishing the foundation for our modern understanding of how populations evolve and species originate.

172. (B) Maintain ion concentration gradients across the membrane.
Ion pumps, such as the sodium-potassium pump, use energy from ATP to move ions against their natural concentration gradients. By continuously pumping specific ions across the membrane, these proteins maintain the chemical and electrical imbalances essential for cellular life. These gradients are used for various processes, including secondary active transport of nutrients, regulation of cell volume, and the generation of electrical signals in excitable cells.

173. (A) Acidic environments are required for enzyme activity.
Lysosomes are filled with a variety of hydrolytic enzymes, such as proteases and nucleases, which are designed to function optimally at an acidic pH of around five. The lysosome maintains this environment using specialized proton pumps. This acidic requirement serves as a safety mechanism; if a lysosome were to break, the enzymes would become inactive in the neutral pH of the surrounding cytoplasm, preventing accidental damage.

174. (D) Polytene chromosome
Polytene chromosomes are exceptionally large chromosomes found in the salivary glands of certain fly larvae. They form through repeated rounds of DNA replication without subsequent cell division, resulting in thousands of sister chromatids aligned side-by-side. These massive structures exhibit distinct, reproducible banding patterns that allow researchers to map genes with high precision and study changes in gene activity by observing the formation of "puffs."

175. (A) Both A and R are true and R is the correct explanation of A.
Polyploidy involves the duplication of an organism's entire set of chromosomes. In plants, this can lead to larger cells and increased genetic flexibility. Crucially, a newly formed polyploid individual often cannot successfully breed with its diploid ancestors, resulting in immediate reproductive isolation. This process allows for the rapid emergence of new species in a single generation, making it a powerful and significant driver of plant evolution and diversity.

176. (D) DNA → RNA → Protein
The Central Dogma of molecular biology describes the fundamental flow of genetic information within all living cells. It posits that DNA serves as the master template for its own replication and for the synthesis of RNA through transcription. This RNA, specifically messenger RNA, then travels to the ribosomes to guide the assembly of amino acids into proteins during translation. This sequence underlies all aspects of cellular gene expression.

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177. (B) Polyploidy (specifically, triploidy).
Polyploidy is a numerical chromosomal abnormality where an organism possesses more than two complete sets of chromosomes. An individual with three sets is specifically termed triploid (3n). While rare and often lethal in humans, triploidy is common in many plant species. Polyploidy results from the fertilization of an abnormal diploid gamete or the fusion of three haploid gametes, leading to a significant increase in total genetic material.

178. (A) Maternal inheritance in most plant species.
Traits determined by genes on plastid DNA, such as those in chloroplasts, do not follow standard Mendelian inheritance patterns. Because the zygote typically receives its entire supply of organelles from the egg cell of the maternal parent, these traits are inherited uniparentally through the maternal line. This means that all offspring will exhibit the plastid-linked traits of their mother, regardless of the genetic contribution from the paternal parent.

179. (B) Show continuous variation in the phenotype.
Polygenic inheritance involves the combined effect of several independent genes on a single trait. Because each gene contributes a small, often additive amount to the final expression, the trait exhibits continuous variation across a wide range, rather than distinct "either-or" categories. Common examples include human height, weight, and skin pigmentation, which show a bell-shaped distribution in populations, reflecting the complex interplay of multiple genetic factors.

180. (B) P-2, Q-3, R-4, S-1
Adaptation is a heritable trait that enhances survival and reproduction in a specific environment. Variation describes the natural differences existing among individuals within a population. Fitness measures an individual's relative reproductive success in passing genes to offspring. Natural selection is the mechanism driving these changes, where individuals with favorable traits survive and reproduce more effectively than those without such traits, leading to population-level evolution.

181. (B) It modulates fluidity, preventing extremes in rigidity.
Cholesterol is a vital lipid component of animal cell plasma membranes. It acts as a bidirectional regulator of membrane fluidity. At high temperatures, it stabilizes the membrane by restricting the movement of phospholipids, preventing it from becoming too fluid. At lower temperatures, it prevents the phospholipids from packing too tightly and solidifying. This modulation ensures that the membrane remains functional and flexible under varying environmental and physiological conditions.

182. (A) Protein synthesis
Ribosomes are the cellular organelles responsible for translating messenger RNA into polypeptide chains. If a drug inhibits ribosome function, the cell's ability to produce new proteins will be halted immediately. Since proteins serve as enzymes, structural components, and signaling molecules, this inhibition would disrupt nearly every metabolic and physiological process, eventually leading to cell death as essential molecules are no longer replenished for vital functions.

183. (C) Chromatin
Chromatin is the complex of DNA and specialized proteins, primarily histones, that makes up the eukaryotic chromosome. Its structure allows the cell to pack a vast amount of genetic information into the tiny volume of the nucleus. The degree of chromatin condensation changes during the cell cycle, being relatively loose during interphase for gene expression and tightly coiled into visible chromosomes during the stages of cell division.

184. (D) A non-dividing state with metabolic activity.
The G0 phase is a specialized state outside the active cell cycle. Cells in this phase have exited the cycle and are no longer preparing for division. While they are not dividing, they remain metabolically active and continue to perform their specific physiological functions in the body. Some cells, like mature neurons, stay in G0 permanently, while others can be stimulated to re-enter the cell cycle for repair.

185. (A) AB and ab (parental types)
When two genes are linked on the same chromosome, their alleles tend to be inherited together as a unit. In a heterozygous individual

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processes, including the transmission of electrical signals in the nervous system and the regulation of osmotic balance within the biological cell.

219. (B) Nucleus and Endoplasmic Reticulum
The Golgi apparatus is a polarized organelle with two distinct faces. The "cis-face" is the receiving side, typically oriented toward the nucleus and the endoplasmic reticulum. It accepts transport vesicles carrying newly synthesized proteins and lipids from the ER. Once received, these materials move through the Golgi cisternae for modification and sorting before being packaged into new vesicles on the opposite "trans-face" for their final delivery.

220. (C) P-3, Q-1, R-4, S-2
The cell cycle is an organized sequence of events leading to division. During G1, the cell grows and prepares for DNA synthesis. The S phase is dedicated to replicating the entire genome. G2 involves further growth and final preparations for the actual division process. Finally, the M phase encompasses mitosis and cytokinesis, where chromosomes are segregated and the cell physically splits into two daughter cells, each with a complete set of genetic material.

221. (B) Metacentric
Chromosomes are classified based on the relative position of their centromere. A metacentric chromosome has its centromere located exactly in the middle, dividing it into two arms of approximately equal length. This gives the chromosome a characteristic "V" shape when it is pulled toward the poles during anaphase of cell division. This symmetrical organization is distinct from submetacentric, acrocentric, or telocentric forms where the centromere is positioned progressively closer to one end.

222. (C) During Prophase I of meiosis.
Crossing over is a pivotal event that occurs specifically during prophase I of meiosis. At this stage, homologous chromosomes pair up in a process called synapsis, forming a complex that allows them to physically exchange segments of genetic material. This reshuffling of alleles between maternal and paternal chromosomes creates recombinant chromatids, which significantly increases the genetic diversity of the resulting gametes and ensures that offspring have unique genetic identities.

223. (D) They allow for alternative splicing of one gene.
Introns are non-coding sequences that interrupt the coding regions, or exons, of many eukaryotic genes. While they are removed during RNA processing, their presence is highly significant. By allowing for alternative splicing, where different combinations of exons are joined together, a single gene can produce multiple distinct proteins. This mechanism vastly increases the protein-making potential and functional complexity of the genome without requiring a larger number of total genes.

224. (A) Fusion of two acrocentric centromeres.
A Robertsonian translocation is a unique type of chromosomal rearrangement that specifically involves acrocentric chromosomes. In this process, the long arms of two non-homologous acrocentric chromosomes fuse at a single centromere, while the very short arms are typically lost. This results in a reduced total chromosome count for the cell. Although often balanced and harmless to the individual, Robertsonian translocations can lead to significant chromosomal imbalances in the next generation.

225. (B) Unique DNA is present once; repetitive is multicopy.
Eukaryotic genomes are composed of different classes of DNA based on their frequency. Unique sequence DNA generally consists of protein-coding genes that are present in only one or a few copies per genome. Repetitive DNA, however, consists of nucleotide sequences that are represented in multiple copies, sometimes numbering in the millions. These repetitive elements can be dispersed throughout the genome or clustered in specific regions like centromeres and telomeres.

226. (B) 16
Mitosis is an equational division process designed to maintain the chromosome number of the parent cell. During mitosis, the cell's DNA is replicated and then divided equally between two daughter cells. If a diploid parent cell starts with 16 chromosomes (2n=16), each resulting daughter cell will also have exactly 16

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other. This test was fundamental in defining the gene as a single functional unit of inheritance, or a cistron.

194. (D) 69
A standard human somatic cell is diploid (2n), containing 46 chromosomes (two sets of 23). An individual who is triploid (3n) possesses three complete sets of chromosomes instead of two. Therefore, their total chromosome count would be 69. Triploidy is a severe chromosomal abnormality in humans, usually resulting from the fertilization of an abnormal egg or by two sperm cells, and is typically incompatible with long-term survival.

195. (D) None of his children.
Mitochondrial DNA is inherited exclusively through the maternal line in humans. This is because the egg cell provides nearly all the cytoplasm and organelles to the zygote, while the sperm contributes only nuclear genetic material. Therefore, if a man has a mutation in his mitochondrial DNA, he cannot pass it to his children. Only a mother with such a mutation would pass the disorder to all her offspring.

196. (A) The environment.
An organism's phenotype, or observable characteristics, is not determined by its genetic makeup alone. Instead, it is the result of the complex interaction between its genotype and its external environment. Factors such as nutrition, light exposure, temperature, and social interactions can all influence how genes are expressed. This flexibility allows organisms to respond to environmental challenges and is a key aspect of biological development and evolutionary adaptation.

197. (A) Thomas Malthus
Charles Darwin's theory of natural selection was significantly influenced by the writings of Thomas Malthus, an economist. Malthus argued that human populations tend to grow exponentially while food production only increases linearly, leading to inevitable competition for survival. Darwin applied this concept to the natural world, realizing that similar pressures exist for all species, ensuring that only individuals with advantageous traits are likely to survive and successfully reproduce.

198. (B) Active transport via ion pumps.
To maintain specific concentrations of ions within different cellular compartments, cells often move ions against their natural electrochemical gradients. This process requires active transport, which utilizes energy, usually in the form of ATP, to power specialized transmembrane proteins called ion pumps. These pumps are highly selective, allowing the cell to meticulously regulate its internal environment and support essential physiological processes like nerve signaling and nutrient uptake in tissues.

199. (A) Phagocytosis
Phagocytosis, or "cell eating," is a specialized form of endocytosis used by cells to engulf large particles, such as food or invading bacteria. The cell extends its plasma membrane around the particle to form a large vesicle called a phagosome, which then fuses with a lysosome for digestion. This process is essential for the immune response in animals and for nutrient acquisition in many unicellular biological organisms.

200. (B) 2, 3, 4, 1
Eukaryotic gene expression follows a precise chronological pathway. It begins with the transcription of DNA into a pre-mRNA molecule in the nucleus. This pre-mRNA then undergoes processing, including the removal of introns. The mature mRNA is subsequently exported through nuclear pores into the cytoplasm. Finally, ribosomes bind to the mRNA and translate its genetic sequence into a polypeptide chain, completing the formation of a functional protein.

201. (C) Synthesis of genetic material
The plasma membrane is a multifunctional barrier essential for life. It manages selective transport of nutrients and wastes, facilitates communication with other cells, and receives signals from the environment. However, it is not involved in the synthesis of genetic material. DNA replication and RNA transcription are specialized processes that occur within the cell nucleus or in organelles like mitochondria and chloroplasts, away from the membrane.

202. (A) Chloroplast
Chloroplasts are complex organelles with a sophisticated internal structure designed for photosynthesis. They contain an intricate system

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(AB/ab), the original combinations (AB and ab) are known as the parental types. During meiosis, these parental gametes will be produced in the highest proportion. Recombinant gametes (Ab and aB) only occur when crossing over happens between the two genes, which is less frequent.

186. (B) Endosymbiotic theory of organelle origin.
The presence of independent DNA and ribosomes within mitochondria strongly supports the endosymbiotic theory. This theory proposes that mitochondria originated as free-living prokaryotes that were engulfed by a larger ancestral cell. Over time, the two organisms developed a symbiotic relationship, with the prokaryote evolving into a specialized organelle. The similarity of mitochondrial genetic machinery to that of modern bacteria provides compelling evidence for this evolutionary event.

187. (A) static worldview to a dynamic one.
The emergence of evolutionary thought marked a profound transition in how humans perceive the natural world. It shifted from a static worldview, which held that species were fixed and Earth was unchanging, to a dynamic one. This new perspective recognized that life is in a constant state of transformation and that Earth has been shaped by slow, continuous processes over vast periods of geological and biological time.

188. (A) A plant growing taller for sunlight than others.
In an evolutionary context, the "struggle for fitness" describes the competition among individuals for limited resources needed to survive and reproduce. A plant growing taller to capture more sunlight than its neighbors is a classic example. If height is a heritable trait and taller plants produce more seeds, the frequency of "tall" genes will increase in the population over generations, illustrating the process of adaptation by natural selection.

189. (A) Pumps Na^+ out and K^+ into the eukaryotic cell.
The sodium-potassium pump is an essential active transport protein found in animal cell membranes. It functions as an antiporter because it moves three sodium ions out of the cell for every two potassium ions it pumps into the cell. This process requires ATP energy and maintains the high sodium and potassium concentration gradients necessary for generating electrical signals and regulating overall cell volume and internal chemical balance.

190. (C) 1 and 3 only
Chromosomal study involves various specialized concepts. A karyotype provides a visual overview of an individual's chromosome number and structure. Transposons are dynamic DNA sequences capable of moving within the genome, contributing to genetic variation. While euchromatin is loosely packed and active, it is heterochromatin that remains highly condensed and inactive. These elements together define the complex organization and regulation of the eukaryotic genome across different cell types.

191. (C) Ribosomes on the surface of the rough ER.
The endoplasmic reticulum consists of two structurally distinct regions. The rough endoplasmic reticulum is distinguished by the presence of numerous ribosomes attached to its outer membrane surface, giving it a characteristic "rough" appearance. These ribosomes are responsible for synthesizing proteins that will be secreted or incorporated into membranes. The smooth endoplasmic reticulum lacks these ribosomes and focuses instead on lipid synthesis, carbohydrate metabolism, and toxin detoxification.

192. (B) Anaphase I
During anaphase I of meiosis, a critical reduction in chromosome number occurs. Unlike mitosis, where sister chromatids separate, in anaphase I, the homologous chromosome pairs are pulled apart toward opposite poles of the cell. The sister chromatids remain attached at their centromeres and move together. This ensuring that each daughter cell receives only one chromosome from each homologous pair, effectively halving the total chromosome count for the cell.

193. (B) If mutations are alleles of the same gene.
The cis-trans test is a functional genetic test used to determine whether two independent recessive mutations occur within the same gene or in different genes. By observing whether a hybrid organism carrying both mutations exhibits a normal or mutant phenotype, scientists can determine if the mutations complement each

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repair, and expand its various membrane systems, including the plasma membrane and the membranes of other organelles.

211. (C) Structural proteins that package and condense DNA.
Histones are a group of highly alkaline proteins found in eukaryotic cell nuclei that package and order DNA into structural units called nucleosomes. They act as the primary spools around which DNA winds, facilitating the immense compaction required to fit the genome into the nucleus. Beyond their structural role, histones also play a key part in regulating gene expression by determining how accessible specific DNA sequences are to transcription.

212. (C) Four diverse haploid cells from one parent cell.
Meiosis is a specialized form of cell division that occurs in two consecutive stages, resulting in the production of four daughter cells. Unlike mitosis, meiosis reduces the chromosome number by half, producing haploid cells. Furthermore, through processes like crossing over and independent assortment, each of these four cells is genetically unique. This diversity is the foundation of sexual reproduction, ensuring that each offspring inherits a novel combination of traits.

213. (D) Aneuploidy, such as Trisomy 13.
A karyotype is a visual chart of all the chromosomes in an individual's cell, allowing scientists to observe their number and structure. It is a powerful tool for diagnosing aneuploidy, a condition where there is an abnormal number of chromosomes. For example, Trisomy 13, which involves having three copies of chromosome 13, is easily identifiable on a karyotype. However, smaller point mutations or single-gene disorders cannot be detected this way.

214. (A) They are stable DNA sequences that never change their location.
Transposons, or "jumping genes," are dynamic DNA sequences that possess the unique ability to move from one location to another within a genome. This mobility can disrupt gene function if they insert into a coding sequence or alter gene regulation if they land near a promoter. By creating new genetic arrangements and mutations, transposons serve as a major source of genetic variation and are significant drivers of genomic evolution.

215. (A) Both A and R are true and R is the correct explanation of A.
Extra-nuclear inheritance is a non-Mendelian pattern of inheritance involving genes found in mitochondria and chloroplasts. Unlike nuclear DNA, which is inherited equally from both parents, these organelles are typically passed to the zygote only through the maternal egg cell. Consequently, the traits they govern do not undergo Mendelian segregation or assortment, and instead follow a maternal lineage, ensuring that all offspring inherit the mother's organelle genotype.

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216. (C) Polygenic inheritance.
Traits such as flower size and scent intensity often exhibit continuous variation, where individuals show a smooth gradient of phenotypes rather than distinct categories. This pattern typically indicates polygenic inheritance, where several different genes contribute small, additive effects to the final expressed characteristic. This complexity allows for subtle differences among individuals and provides a broad range of variation upon which artificial or natural selection can act in populations.

217. (B) Jean-Baptiste Lamarck
The classic example of giraffes stretching their necks to reach high foliage and passing those acquired long necks to their offspring illustrates Lamarck's theory of inheritance of acquired characteristics. Lamarck believed that an organism's physical changes during its life, driven by environmental needs and use, could be inherited by the next generation. While this specific mechanism was later proven incorrect by modern genetics, it was an early attempt to explain adaptation.

218. (A) To allow specific ions to pass down their gradient.
Ion channels are specialized transmembrane proteins that form narrow, water-filled pores across the plasma membrane. Their primary role is to facilitate the rapid and selective movement of specific ions, such as sodium or potassium, down their electrochemical gradients. This passive transport is essential for many physiological

of flattened membrane sacs called thylakoids, which are stacked into structures known as grana. These thylakoids house the light-capturing pigments. The surrounding fluid-filled space is the stroma, where the enzymes for the Calvin cycle are located. This compartmentalization allows for the efficient conversion of light energy into chemical energy in plants.

203. (B) Silent mutation
A silent mutation occurs when a single nucleotide in a DNA sequence is changed, but the resulting codon still codes for the same amino acid. This is possible due to the redundancy of the genetic code. Because the primary structure of the protein remains unchanged, the mutation typically has no observable effect on the organism's phenotype. Silent mutations contribute to the genetic diversity of a population without altering protein function.

204. (A) Bind to and activate CDKs to control the cell cycle.
Cyclins are a family of regulatory proteins that play a central role in controlling the progression of the cell cycle. Their concentrations fluctuate in a predictable pattern throughout the cycle. By binding to and activating cyclin-dependent kinases, cyclins trigger the phosphorylation of target proteins that initiate key events, such as DNA replication or spindle formation. This mechanism ensures that the cell cycle proceeds in a specific and orderly manner.

205. (C) A homozygous recessive individual.
A test cross is a fundamental genetic tool used to determine the genotype of an individual expressing a dominant trait. By crossing this unknown individual with a homozygous recessive partner, the researcher can observe the offspring's phenotypes. If any offspring show the recessive trait, the unknown parent must be heterozygous. If all offspring show the dominant trait, the unknown parent is likely homozygous dominant, revealing its true genetic makeup.

206. (B) Co-regulated genes are transcribed as one mRNA.
An operon is a functional unit of genomic DNA found in prokaryotes, where multiple genes involved in the same metabolic pathway are clustered together. These genes are under the control of a single promoter and are transcribed as a single, large messenger RNA molecule. This arrangement allows the bacterium to efficiently coordinate the expression of related enzymes, turning them on or off simultaneously in response to environmental changes.

207. (D) Includes the centromere.
A pericentric inversion is a type of chromosomal rearrangement where a segment of DNA is flipped 180 degrees, and the inverted region includes the chromosome's centromere. While no genetic material is typically lost, the centromere's position may shift, potentially altering the chromosome's appearance and behavior during cell division. Such inversions are significant because they can lead to complex chromosomal imbalances and reduced fertility during the process of meiosis.

208. (A) Genetics and population biology
The evolutionary synthesis represented a monumental shift in biological science by unifying Darwin's theory of natural selection with the principles of Mendelian genetics and the mathematical frameworks of population biology. This integration explained how genetic variation is maintained in populations and how it serves as the raw material for gradual evolutionary change. It provided a comprehensive and scientifically rigorous foundation for our modern understanding of how life evolves.

209. (C) A cell wall in the plant cell.
When placed in a hypotonic solution, both plant and animal cells experience an influx of water due to osmosis. An animal cell, bounded only by a flexible plasma membrane, will swell and eventually burst. In contrast, the rigid cell wall of a plant cell provides structural resistance, preventing the cell from over-expanding. This creates turgor pressure, which is essential for maintaining the plant's upright posture and overall physical stability.

210. (C) Smooth ER
The smooth endoplasmic reticulum is the primary site for the biosynthesis of phospholipids, cholesterol, and other lipid components essential for cell membranes. Unlike the rough ER, it lacks ribosomes and focuses on metabolic processes rather than protein synthesis. Its role in lipid production ensures that the cell can maintain,

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chromosomes. This ensures that every new cell in the tissue has a complete and identical set of genetic instructions for proper function.

227. (A) 8
Meiosis is a specialized reductional division that produces gametes for sexual reproduction. Its primary purpose is to halve the chromosome number so that the original diploid number can be restored upon fertilization. If a diploid cell with 16 chromosomes (2n=16) undergoes meiosis, it will produce haploid gametes, each containing only 8 chromosomes (n=8). This process ensures genetic stability and introduces variation across successive generations of a species.

228. (D) Mitochondrion
The endomembrane system is a coordinated network of internal membranes in eukaryotic cells that work together to synthesize, modify, and transport lipids and proteins. This system includes the nuclear envelope, endoplasmic reticulum, Golgi apparatus, and lysosomes. Mitochondria, however, are not part of this network. They are semi-autonomous organelles with their own double membranes, DNA, and ribosomes, reflecting their distinct evolutionary origin as ancient endosymbiotic bacteria.

229. (C) The separation of sister chromatids.
Anaphase is a short but critical stage of mitosis characterized by the sudden and coordinated separation of sister chromatids. The centromeres split, and the individual chromatids, now considered full chromosomes, are pulled toward opposite poles of the cell by the shortening spindle fibers. This precise movement ensures that each of the two future daughter cells will receive an identical and complete set of genetic information necessary for life.

230. (B) 1 and 2 only
Membrane transport involves several distinct processes. Active transport is an energy-intensive mechanism that moves substances against their concentration gradients using ATP. Passive processes include simple diffusion, where small nonpolar molecules pass directly through the lipid bilayer, and facilitated diffusion, which uses protein channels. While osmosis is the movement of water, the fundamental difference between simple and facilitated diffusion is the requirement for a carrier protein to assist the movement.

231. (B) Synthesize proteins
Ribosomes are essential cellular machines found in all living organisms. Their primary role is to serve as the site of protein synthesis, a process known as translation. Ribosomes read the genetic information carried by messenger RNA and use it to assemble amino acids in the precise order needed to build a functional polypeptide chain. Without ribosomes, a cell would be unable to produce the enzymes and structural proteins necessary for survival.

232. (B) Lactose (or allolactose)
In the lac operon of bacteria, lactose acts as the inducer molecule that regulates gene expression. When lactose is present, it (or its isomer allolactose) binds to the repressor protein, causing it to change shape and release from the operator site on the DNA. This allows RNA polymerase to transcribe the genes needed for lactose metabolism. This elegant system ensures that the bacterium produces specific enzymes only when their substrate is available.

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233. (C) The loss of a segment of a chromosome.
A chromosomal deletion is a structural abnormality resulting from the physical loss of a piece of a chromosome. Depending on the size and location, a deletion can remove a single gene or a large block of genes. Such losses often lead to serious developmental problems or genetic disorders because the individual is missing essential instructions. Terminal deletions occur at the chromosome's end, while interstitial deletions occur within the chromosome's interior.

234. (A) A heritable trait that increases fitness.
In evolutionary biology, an adaptation is a specific heritable characteristic that has evolved over time because it improves an organism's ability to survive and reproduce in its environment. Adaptations can be physical structures, physiological processes, or behavioral patterns. By increasing an individual's fitness, these traits are favored by natural selection, causing them to become more common in the population as the species becomes better suited to its ecological niche.

251. (B) Linkage
Linkage is the phenomenon where genes located physically close to each other on the same chromosome tend to be inherited together as a unit. Because of their proximity, they are less likely to be separated by crossing over during meiosis. This serves as a significant exception to Mendel's Law of Independent Assortment, which only applies to genes that are on different chromosomes or located far apart on the same chromosome, allowing for frequent recombination.

252. (B) Chromosomes cannot pair homologous sets properly.
Triploid organisms (3n) possess three complete sets of chromosomes. During meiosis, successful division requires that homologous chromosomes pair up in two-by-two sets. Because there is an odd number of chromosome sets, they cannot pair correctly, leading to an unbalanced distribution of chromosomes in the resulting gametes. This chromosomal imbalance usually results in highly aneuploid gametes, which typically leads to sterility in triploid animals and significantly reduced fertility in most triploid plant species.

253. (B) A small, circular DNA molecule.
Mitochondria possess their own independent genetic material, known as mitochondrial DNA. This DNA is structured as a small, circular molecule, which is much simpler than the linear chromosomes found in the cell nucleus. This circular architecture, along with the presence of specialized ribosomes, provides strong evidence for the endosymbiotic theory, suggesting that mitochondria evolved from ancient free-living bacteria that were engulfed by a primitive ancestral eukaryotic cell.

254. (B) Codominance of both alleles in the trait.
Codominance is a pattern of inheritance where both alleles in a heterozygous individual are fully and independently expressed in the phenotype. In the case of roan cattle, the alleles for red hair and white hair are both active, resulting in a coat that contains a mixture of both red and white individual hairs. This is distinct from incomplete dominance, where the traits would blend to form a completely new, intermediate color like pink.

255. (A) Both A and R are true and R is the correct explanation of A.
The plasma membrane is described as selectively permeable because it meticulously regulates which substances can enter or leave the cell. This selectivity is primarily due to the hydrophobic nature of the lipid bilayer, which acts as a barrier to most polar and charged molecules. Additionally, specific transmembrane transport proteins, such as channels and pumps, provide controlled pathways for essential nutrients and ions, allowing the cell to maintain its unique internal environment.

256. (D) Lysosome: site of protein synthesis
Cellular organelles perform highly specialized tasks essential for homeostasis. The nucleus stores genetic information, mitochondria produce ATP through respiration, and chloroplasts carry out photosynthesis. However, lysosomes are not involved in protein synthesis; instead, they serve as the cell's waste disposal system, containing hydrolytic enzymes to digest macromolecules and old organelles. Protein synthesis is the specialized function of ribosomes, which can be found in the cytoplasm or on the rough endoplasmic reticulum.

257. (A) The nucleosome
The nucleosome is the fundamental repeating unit of chromatin organization in eukaryotic cells. It consists of a segment of DNA, approximately 147 base pairs long, wrapped twice around a core of eight histone proteins. This "beads on a string" arrangement is the first level of DNA compaction, allowing the massive genome to be organized and fitted into the cell nucleus. Nucleosomes also play a vital role in regulating gene access and transcriptional activity.

258. (C) Maturation-promoting factor (MPF).
The transition from the G2 phase to the M phase of the cell cycle is a tightly regulated event. It is triggered by the activation of a protein complex known as Maturation-promoting factor, which consists of a cyclin-dependent kinase bound to a mitotic cyclin. Once activated, MPF phosphorylates a variety of target proteins that initiate key mitotic processes, such as nuclear envelope breakdown, chromosome condensation, and the assembly of the mitotic spindle for cell division.

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243. (B) Aneuploidy of the sex chromosomes.
Klinefelter syndrome is a genetic condition in humans where a male is born with an extra copy of the X chromosome, resulting in a 47,XXY genotype. This is an example of aneuploidy, specifically trisomy of the sex chromosomes. It typically occurs due to an error called nondisjunction during the formation of gametes in one of the parents. The presence of the extra X chromosome alters male physical development and can affect fertility and hormone levels.

244. (A) Failure of antibiotic therapies in medicine.
Plasmids are small, circular DNA molecules that often carry genes providing a selective advantage to bacteria, such as those for antibiotic resistance. Because bacteria can easily exchange plasmids through a process called conjugation, resistance can spread rapidly through a population or even between different species. This horizontal gene transfer is a major factor in the rise of "superbugs," leading to the failure of common antibiotic treatments in clinical settings.

245. (A) 25%
When two parents are heterozygous carriers (Aa) for a recessive disorder, each has a fifty percent chance of passing the recessive allele (a) to their offspring. According to the laws of probability, there is a twenty-five percent chance that a child will inherit a recessive allele from both parents (aa), thereby expressing the disorder. This 1:2:1 genotypic ratio is a fundamental predictable outcome of a Mendelian cross between two heterozygous individuals.

246. (A) Alter arrangements and expression for selection.
Structural changes in chromosomes, such as deletions, duplications, inversions, and translocations, play a significant role in evolution. By rearranging the order of genes or changing the number of gene copies, these mutations can alter gene expression and regulation. While some changes are harmful, others can create novel genetic combinations or provide new material for evolutionary innovation. Natural selection then acts on these variations, potentially leading to the emergence of new traits and species.

247. (A) Darwinian evolution and Mendelian genetics.
The evolutionary synthesis was a landmark intellectual achievement that bridged the gap between Charles Darwin's theory of natural selection and Gregor Mendel's discovery of the laws of inheritance. It demonstrated that the discrete nature of Mendelian genes is consistent with the gradual process of evolutionary change. This unification, bolstered by mathematical models from population genetics, provided a comprehensive and robust framework for understanding how genetic variation drives the evolution of life on Earth.

248. (A) Regulate molecule movement between nucleus and cytoplasm.
The nuclear pore complex is a large, sophisticated protein structure that spans the double membrane of the nuclear envelope. Its primary role is to serve as a selective gatekeeper, meticulously regulating the transport of materials between the nucleus and the cytoplasm. It allows the passive diffusion of small molecules while actively transporting larger molecules, such as RNA and proteins, ensuring that transcription and translation are spatially and temporally coordinated.

249. (C) Ribosome
While many organelles like mitochondria, lysosomes, and peroxisomes are bounded by lipid membranes to compartmentalize their functions, the ribosome is a non-membrane-bound structure. It is composed of a complex of ribosomal RNA and proteins. This unique organization allows ribosomes to be found both free in the cytoplasm and attached to the rough endoplasmic reticulum, where they are essential for the fundamental process of translating genetic information into functional proteins.

250. (A) 2C to 4C
The S phase, or synthesis phase, is the specific period of the cell cycle dedicated to the replication of all genomic DNA. At the start of this phase, a typical diploid cell has a DNA content of 2C. By the time replication is complete, the total amount of DNA has doubled to 4C. This ensures that the cell has two complete sets of genetic information, which can then be divided equally between the two daughter cells during mitosis.

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235. (C) The theory of evolution
The concept of common descent is a cornerstone of the theory of evolution. It posits that all living organisms on Earth share a common ancestry and have diversified over billions of years through processes like natural selection and genetic drift. This theory explains the fundamental similarities in the biochemistry, genetics, and cell structures found across the diverse tree of life, linking all species together in a single, complex evolutionary history.

236. (A) Require the use of specific transport proteins.
Facilitated diffusion and active transport both rely on specialized transmembrane proteins to move substances across the cell membrane. These proteins, whether channels or carriers, provide a selective pathway for molecules that cannot pass directly through the hydrophobic lipid bilayer. However, they differ in their energy requirements; facilitated diffusion is a passive process that follows a concentration gradient, while active transport uses cellular energy to move substances against a gradient.

237. (C) Cytoskeleton
The cytoskeleton is a dynamic network of protein filaments extending throughout the cytoplasm of eukaryotic cells. It consists of microtubules, microfilaments, and intermediate filaments. This internal scaffolding provides essential structural support, maintains cell shape, and anchors organelles in place. Furthermore, the cytoskeleton is crucial for various types of movement, including the transport of vesicles within the cell, the segregation of chromosomes during division, and overall cellular motility and contraction.

238. (A) Heterozygous
An individual's genotype is described as heterozygous for a particular gene if they possess two different alleles at that locus. Typically, one allele is inherited from the maternal parent and the other from the paternal parent. In classical Mendelian genetics, the heterozygous individual often expresses the dominant phenotype, while the recessive allele remains present but unexpressed. This genetic variation is a fundamental source of the phenotypic diversity observed in biological populations.

239. (B) Meiosis I
The separation of homologous chromosomes is the hallmark event of meiosis I. During this first stage of meiotic division, the paired homologous chromosomes, each consisting of two sister chromatids, are pulled apart and move to opposite poles of the cell. This process is known as segregation and is responsible for reducing the chromosome number from diploid to haploid, which is essential for maintaining the correct chromosome count in the next generation.

240. (C) Alfred Russel Wallace
The theory of evolution by natural selection was co-developed by Charles Darwin and Alfred Russel Wallace. While Darwin had been developing his ideas for decades, Wallace independently arrived at the same mechanism after observing the distribution of species in Southeast Asia. In 1858, their findings were presented together to the Linnean Society of London. This joint discovery provided a powerful explanation for how populations adapt to their environments and how new species originate.

241. (B) Maintaining water balance via osmoregulation.
In freshwater protozoa like Paramecium, the surrounding environment is hypotonic, causing a continuous influx of water by osmosis. To prevent the cell from swelling and bursting, these organisms utilize a specialized organelle called a contractile vacuole. This vacuole periodically collects excess water from the cytoplasm and then contracts to expel it through a pore in the plasma membrane. This active process of osmoregulation is vital for survival in freshwater habitats.

242. (A) An allele is a variant form of a gene.
A gene is a specific sequence of DNA that provides the instructions for a particular trait or functional product. Within a population, a gene can exist in slightly different versions, which are known as alleles. For example, a single gene might determine flower color, but one allele could code for red while another codes for white. These variations arise through mutation and contribute to the genetic and phenotypic diversity seen among individuals of a species.

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259. (B) Exchange between non-homologous chromosomes.
A reciprocal translocation is a type of structural chromosomal mutation where segments are exchanged between two different, non-homologous chromosomes. While the total number of genes often remains unchanged, the new arrangement can disrupt gene regulation at the break points. Furthermore, individuals with balanced reciprocal translocations often have difficulty producing healthy gametes, as the rearranged chromosomes may not pair and segregate correctly during the complex process of meiosis, potentially leading to infertility.

260. (A) P-4, Q-1, R-3, S-2
Genetics involves several key terms. Genotype refers to an organism's underlying genetic makeup, while phenotype describes its observable traits. An allele is one of several alternative forms of a specific gene. The locus is the precise physical location of that gene on a chromosome. Understanding these definitions is essential for studying how traits are inherited and how genetic variation contributes to the diversity of life observed in biological populations and species.

261. (B) Gregor Mendel
Gregor Mendel's pioneering work on the inheritance of traits in pea plants was published in 1866 but remained largely ignored by the scientific community for decades. His discovery of discrete "heritable factors" and the laws of segregation and independent assortment was rediscovered in 1900. This event provided the missing genetic mechanism for Darwin's theory of natural selection and was a cornerstone in the development of the Modern Evolutionary Synthesis.

262. (A) Turgid
When a plant cell is placed in a hypotonic solution, which has a lower solute concentration than the cell's interior, water moves into the cell by osmosis. The influx of water fills the large central vacuole, causing the cell to expand. The rigid cell wall resists this expansion, creating internal pressure known as turgor pressure. This makes the cell turgid, which is the ideal state for providing structural support and keeping the plant upright.

263. (C) Synthesize, modify, and transport lipids and proteins.
The endomembrane system is an integrated network of membranes in eukaryotic cells, including the nuclear envelope, endoplasmic reticulum, Golgi apparatus, and lysosomes. Its primary role is to coordinate the synthesis, chemical modification, and delivery of proteins and lipids. This system ensures that molecules are correctly processed and packaged into vesicles for transport to their final destinations, whether they are within the cell's various compartments or intended for secretion into the extracellular environment.

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264. (B) A gene is a DNA segment on a chromosome.
The relationship between a gene and a chromosome is one of structural organization. A chromosome is a very long, continuous thread of DNA that contains hundreds or thousands of individual genes arranged in a specific linear order. Each gene is a distinct segment of that DNA that codes for a specific protein or functional RNA molecule. In eukaryotic cells, these chromosomes are housed within the nucleus and are highly organized using specialized packaging proteins.

265. (A) Meiosis via crossing over and assortment.
In sexually reproducing populations, genetic variation is primarily generated through the process of meiosis. Two key events contribute to this diversity: crossing over, where homologous chromosomes exchange genetic segments, and independent assortment, where maternal and paternal chromosomes are distributed randomly to gametes. These processes, combined with the random fusion of gametes during fertilization, ensure that every offspring possesses a unique combination of alleles, providing the raw material for natural selection.

266. (C) Aneuploidy
Aneuploidy is a type of chromosomal abnormality where a cell has an atypical number of individual chromosomes. In humans, this means having more or fewer than the normal 46 chromosomes, such as 45 (monosomy) or 47 (trisomy). This condition typically arises from nondisjunction, where chromosomes fail to separate properly during meiosis. Aneuploidy often leads to significant developmental issues or genetic

disorders, such as Down syndrome or Turner syndrome, due to imbalanced gene dosage.

267. (A) Mitochondria were once free-living prokaryotes.
The discovery that mitochondria contain their own circular DNA, ribosomes, and independent replication machinery provided powerful support for the endosymbiotic theory. This theory proposes that mitochondria originated as independent, free-living prokaryotic organisms that were engulfed by a larger ancestral cell. Over time, the two developed a mutually beneficial relationship, and the prokaryote evolved into the specialized energy-producing organelle found in nearly all modern eukaryotic cells. This evolutionary history explains their unique genetic properties.

268. (A) Gamete formation (meiosis)
Mendel's Law of Segregation states that every individual possesses two alleles for each gene, which must separate during the formation of gametes. This process occurs during meiosis, ensuring that each reproductive cell carries only one allele for every trait. When fertilization occurs, the offspring inherits one allele from each parent, restoring the diploid state. this principle explains why traits that seem to disappear in one generation can reappear in the next.

269. (B) A polygenic trait
A polygenic trait is one whose phenotype is influenced by the collective effects of two or more independent genes. Unlike Mendelian traits, which often show discrete categories, polygenic traits typically exhibit continuous variation in a population, with most individuals falling near the average. Human characteristics like skin color, height, and intelligence are classic examples of polygenic inheritance, where each contributing gene adds a small, cumulative effect to the final expressed characteristic of the individual.

270. (B) 1 and 2 only
Evolutionary science is built on several foundational concepts. Natural selection acts on existing phenotypic variation, which ultimately originates from random mutations. Lamarck pioneeringly suggested that species change over time, though his mechanism of inheritance of acquired characteristics was later disproven. In evolution, fitness describes an individual's relative reproductive success, not just its physical strength. Together, these ideas illustrate the complex history of our understanding of how life adapts and diversifies over time.

271. (C) Channel protein for water
An aquaporin is a specialized type of transmembrane channel protein that facilitates the rapid and selective movement of water molecules across the cell membrane. While water can slowly diffuse through the lipid bilayer, aquaporins allow for much higher rates of transport, which is essential in tissues that regulate water balance, such as the kidneys. These channels are highly specific, allowing water to pass while preventing the movement of ions and other solutes.

272. (B) Lysosome
Lysosomes play a critical role in the process of autophagy, which is the cell's internal recycling system. During autophagy, the cell sequesters old, damaged, or redundant organelles and proteins within a double-membrane vesicle called an autophagosome. This vesicle then fuses with a lysosome, whose hydrolytic enzymes break down the contents into basic molecular building blocks. This process is essential for maintaining cellular health, managing stress, and providing raw materials for the synthesis of new components.

273. (B) Accurate segregation to daughter cells.
During most of the cell cycle, DNA exists as loose chromatin to allow for transcription and replication. However, as the cell enters mitosis, the chromatin condenses into its most compact form. This highly condensed state is necessary for the accurate segregation of chromosomes. Tightly coiled chromosomes are more manageable for the spindle fibers and less likely to break or become tangled as they are pulled toward opposite poles of the dividing cell.

274. (C) G0 phase
The G0 phase is a state of dormancy where a cell has exited the active cell cycle and is no longer preparing for division. Many terminally differentiated cells, such as mature neurons and heart muscle cells, enter this state permanently once they have achieved their final functional form. While these cells remain metabolically

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active and perform their specialized roles in the body, they typically lose the ability to divide, meaning they are not easily replaced if damaged.

275. (C) The distance between two genes on a chromosome.
In a two-point test cross, the frequency of recombinant offspring is used as a direct measure of the genetic distance between two linked genes. Because crossing over is more likely to occur between genes that are farther apart, a higher recombination frequency indicates a greater physical distance on the chromosome. This principle allowed early geneticists to develop the first linkage maps, showing the relative linear order and spacing of genes along individual chromosomes.

276. (C) Inversion
Chromosomal abnormalities are categorized as either numerical or structural. Numerical changes, such as trisomy, monosomy, and polyploidy, involve an abnormal total number of chromosomes. In contrast, structural changes involve rearrangements of the chromosome itself. An inversion is a structural mutation where a segment of a chromosome breaks off, flips 180 degrees, and reattaches. Although the gene number might stay the same, the altered sequence can disrupt regulation or cause issues during the process of meiosis.

277. (A) A single, circular molecule.
Chloroplasts, the organelles responsible for photosynthesis in plants and algae, contain their own independent genetic material. This chloroplast DNA is typically organized as a single, circular molecule, which is much smaller than the linear chromosomes found in the cell nucleus. This circular structure is highly characteristic of prokaryotic genomes, providing strong evidence that chloroplasts originated from ancestral cyanobacteria that were engulfed by an ancient eukaryotic host through the process of endosymbiosis.

278. (A) Type AB
Human blood types are determined by a gene with three alleles: A, B, and O. The A and B alleles are codominant, meaning that both are fully expressed when present together. If a father is homozygous for type A (AA) and a mother is homozygous for type B (BB), each child will inherit an A allele from the father and a B allele from the mother. Consequently, all their children will have the AB blood type, expressing both antigens.

279. (B) Natural selection
The development of antibiotic resistance in bacteria is a classic example of natural selection occurring in real-time. Within any bacterial population, rare mutations may happen to provide resistance to a specific drug. When the population is exposed to that antibiotic, the non-resistant bacteria are killed, while the resistant individuals survive and reproduce. Over time, the resistant strain becomes dominant, illustrating how environmental pressures can rapidly shift the genetic makeup of a population of biological organisms.

280. (2, 4, 3, 1)
The origin of life and cellular complexity followed a logical progression over billions of years. Initially, simple organic molecules were synthesized from inorganic precursors in the early Earth environment. These molecules eventually became enclosed within protocells, which then evolved into the first prokaryotic organisms. Much later, complex eukaryotic cells emerged through endosymbiosis, incorporating specialized membrane-bound organelles for advanced metabolic functions. This sequence highlights the increasing complexity and organization of biological life throughout its evolutionary history.

281. (A) Peptidoglycan in bacteria and cellulose in plants.
Cell walls provide essential structural support but differ chemically across domains. Bacterial cell walls are primarily composed of peptidoglycan, a complex polymer of sugars and amino acids. In contrast, plant cell walls are made of cellulose, a robust polysaccharide. These distinct chemical foundations reflect the divergent evolutionary paths of these organisms and are crucial for identifying species and understanding how they interact with their environments and respond to medical treatments like antibiotics.

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282. (A) Potential energy
The electrical potential across a biological membrane, often called the membrane potential, is a form of potential energy. It is created by the unequal distribution of ions and is maintained by active transport proteins. This stored energy is like a battery, ready to be utilized by the cell. When ion channels open, this potential energy is converted into the kinetic energy of moving ions, powering essential processes like nutrient uptake and the transmission of electrical impulses.

283. (D) Exocytosis
Exocytosis is a vital cellular process used to transport large molecules, such as proteins and neurotransmitters, out of the cell. The materials are first packaged into membrane-bound secretory vesicles. These vesicles then move to the plasma membrane and fuse with it, releasing their contents into the extracellular space. This mechanism is essential for cell-to-cell communication, the release of hormones, and the export of components needed for the extracellular matrix or cell wall.

284. (C) Two sister chromatids joined at a centromere.
In its most condensed state during metaphase, a eukaryotic chromosome consists of two identical copies of DNA, known as sister chromatids. These chromatids are produced during the S phase and remain tightly held together at a specialized region called the centromere. This highly organized, compact structure is essential for ensuring that the genetic material can be moved and divided accurately between the two daughter cells during the complex stages of mitosis and meiosis.

285. (B) Homologous chromosomes cannot pair in the inverted region.
Chromosomal inversions can effectively suppress crossing over in heterozygous individuals. For crossing over to occur during meiosis, homologous chromosomes must align perfectly. In the region of an inversion, the gene sequences are in reverse order, which prevents normal pairing. While a complex "inversion loop" may form, any crossover within it often leads to highly unstable, aneuploid gametes. Consequently, the genes within the inverted segment are typically inherited together as a single linked block.

286. (A) To see if a dominant individual is homozygous or heterozygous.
A test cross is a fundamental technique in classical genetics used to reveal the genotype of an individual that displays a dominant phenotype. Because a dominant trait can result from either a homozygous dominant or a heterozygous genotype, the unknown individual is crossed with a homozygous recessive partner. The resulting phenotypic ratio among the offspring provides clear evidence: if any recessive offspring appear, the unknown parent must be heterozygous; if not, it is likely homozygous dominant.

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287. (D) Inheritance of acquired characteristics
Darwin's theory of evolution is based on three fundamental pillars: heritable variation within a population, the struggle for existence due to limited resources, and the differential survival and reproduction of individuals with favorable traits. While he understood that variation was necessary, he did not correctly identify its source. The inheritance of acquired characteristics was actually a central tenet of Lamarck's earlier theory, which Darwin's model of natural selection eventually superseded as the dominant scientific explanation.

288. (B) More active
In a saltwater environment, the external solute concentration is high, which naturally draws water out of the cell through osmosis. When moved to fresh water, which is hypotonic, water will instead rush into the cell. To prevent the cell from swelling and bursting due to this increased water influx, a single-celled organism like an amoeba must increase the activity of its contractile vacuole to pump the excess water out more frequently, maintaining proper internal balance.

289. (A) Cilia and flagella in eukaryotic cells.
The '9 + 2' arrangement is a highly conserved structural feature found in the cilia and flagella of most eukaryotic cells. It consists of a ring of nine outer microtubule doublets surrounding two central singlet microtubules. This complex structure, anchored by a basal body, is essential for the characteristic waving or beating motion of these organelles. It facilitates various functions, including cellular motility, moving fluids across

tissue surfaces, and capturing food particles from the environment.

290. (A) Coding sequence split by non-coding introns.
An "interrupted gene" is a hallmark feature of eukaryotic genomes, where the coding sequences, or exons, are not continuous. Instead, they are interrupted by non-coding segments called introns. During the process of gene expression, the entire gene is transcribed, and the introns are then meticulously removed through a process called RNA splicing. This organization allows for alternative splicing, which is a major mechanism for increasing the functional diversity of proteins produced by the cell.

291. (C) Two diploid cells
Mitosis is a form of equational cell division that ensures genetic continuity. During this process, a diploid parent cell replicates its entire genome and then divides once to distribute the material equally. The result is two daughter cells that are genetically identical to each other and possess the same diploid number of chromosomes as the original parent cell. This consistency is essential for growth, tissue maintenance, and the repair of somatic cells in multicellular biological organisms.

292. (C) Trisomy
A typical human cell is diploid and contains 46 chromosomes. When an individual has 47 chromosomes, it is because they possess an extra copy of one specific chromosome, a condition known as trisomy. This is a type of aneuploidy that usually results from nondisjunction during the formation of a parent's gametes. The extra genetic material disrupts the normal balance of gene expression, leading to various developmental issues and clinical conditions, such as Down syndrome.

293. (B) End symbiosis
The endosymbiotic theory posits that mitochondria and chloroplasts originated as free-living bacteria that were engulfed by a larger ancestral cell. The most compelling evidence for this is that these organelles possess their own independent circular DNA and ribosomes, which are strikingly similar to those found in modern prokaryotes. This internal genetic machinery allows them to replicate independently and produce some of their own proteins, reflecting their ancestral history as independent organisms before becoming integrated cellular components.

294. (B) The principle of dominance
Mendel's principle of dominance states that in a cross between two pure-breeding parents for a trait, one allele can mask the expression of the other in the resulting F1 generation. In this case, the allele for "tall" is dominant over the allele for "short." Although the offspring are heterozygous and carry both alleles, only the tall phenotype is visible. This principle explains the predictable phenotypic outcomes observed in many simple Mendelian inheritance patterns across diverse species.

295. (B) The evolutionary synthesis
The evolutionary synthesis, also known as the Modern Synthesis, was a pivotal movement in 20th-century biology. it successfully integrated Charles Darwin's theory of natural selection with Gregor Mendel's principles of particulate inheritance and the mathematical insights of population genetics. This unification provided a comprehensive explanation for how genetic variation is maintained in populations and how it drives both small-scale adaptation and the larger patterns of species formation and macroevolution throughout biological history.

296. (C) Depends on binding molecules to membrane proteins.
Receptor-mediated endocytosis is a highly selective transport mechanism. Unlike phagocytosis or pinocytosis, which are relatively non-specific, this process depends on specific external molecules binding to matching receptor proteins on the plasma membrane. Once bound, these receptors cluster together, and the membrane invaginates to form a coated vesicle. This allows the cell to concentrate and internalize large quantities of specific substances, such as cholesterol or hormones, even when they are at low external concentrations.

297. (B) Detoxification of various drugs and poisons.
The smooth endoplasmic reticulum is highly developed in specialized tissues like the liver. One of its most critical roles is the detoxification of various drugs, metabolic wastes, and environmental poisons. Enzymes within the

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smooth ER membrane chemically modify these substances to make them more water-soluble, allowing them to be more easily excreted from the body. This protective function is essential for maintaining physiological health and managing exposure to potentially harmful chemical substances.

298. (C) Telomeres
Telomeres are specialized, repetitive DNA sequences located at the extreme ends of linear eukaryotic chromosomes. They function as protective caps that prevent the chromosome from unravelling or accidentally fusing with other chromosomes. Furthermore, telomeres solve the end-replication problem by ensuring that vital genetic information is not lost during successive rounds of DNA replication. The progressive shortening of telomeres with each cell division is closely associated with cellular aging and the limits of biological tissue regeneration.

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299. (C) Crossing over
Crossing over is a fundamental genetic event that occurs during prophase I of meiosis. It involves the physical exchange of corresponding DNA segments between non-sister chromatids of homologous chromosome pairs. This process shuffles the alleles inherited from the maternal and paternal parents, creating new and unique combinations of traits. By generating recombinant chromosomes, crossing over significantly increases the genetic diversity of the resulting gametes, which is a key driver of variation in sexually reproducing species.

300. (B) Microevolution
Microevolution refers to the subtle changes in the genetic makeup of a population that occur over relatively short periods. These shifts are characterized by changes in allele frequencies due to processes like natural selection, mutation, genetic drift, and gene flow. While microevolution may not lead to the immediate formation of new species, these incremental changes represent the foundational evolutionary processes that, over vast amounts of time, accumulate to produce the broader patterns of diversification and speciation.

CHAPTER 09
Molecular Genetics

1. Which of the following best defines the C-value paradox?
(A) The theory that organismal complexity is directly proportional to genome size.
(B) The lack of correlation between genome size and biological complexity.
(C) The observation that DNA content is constant within a species' somatic cells.
(D) The concept that repetitive DNA sequences determine total organismal complexity.

2. Identify the incorrect statement regarding the structure of B-DNA.
(A) It predominates under conditions of high salt or dehydration.
(B) It possesses a characteristic right-handed double-helical structure.
(C) It contains approximately 10.5 base pairs for every helical turn.
(D) The major groove is wide and deep, while the minor groove is narrow.

3. Which of the following enzymes is primarily responsible for synthesizing the new DNA strand during replication in E. coli?
(A) DNA Polymerase I
(B) DNA Polymerase II
(C) DNA Polymerase III
(D) DNA Ligase

4. Given below are two statements:
Statement I: Transcription activators are proteins that bind to specific DNA sequences to facilitate the initiation of transcription.
Statement II: Transcription repressors bind to silencer sequences to prevent or reduce transcription.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

5. Which of the following is NOT a post-translational modification of proteins?
(A) Phosphorylation
(B) Glycosylation
(C) Splicing
(D) Ubiquitination

6. Match List I (Form of DNA) with List II (Characteristic Feature) and select the correct answer using the options given below:
List I: (Form of DNA)
P. A-DNA
Q. B-DNA
R. Z-DNA
S. C-DNA
List II: (Characteristic Feature)
1. Left-handed helix
2. Prevalent under dehydrating conditions
3. Biologically most common form
4. 9.3 base pairs per turn
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-1, S-2

7. The process by which a virus transfers genetic material from one bacterium to another is known as:
(A) Transformation
(B) Conjugation
(C) Transfection
(D) Transduction

8. What is the primary function of aminoacyl-tRNA synthetase?
(A) Attaches the correct amino acid to its corresponding tRNA molecule.
(B) Synthesizes specific tRNA molecules directly from a DNA template.
(C) Catalyzes peptide bond formation between amino acids during translation.

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(D) Facilitates the translocation of the ribosome along the mRNA strand.

9. The concept of "hybrid vigour" or heterosis refers to:
(A) The increased susceptibility of specific hybrid offspring to environmental diseases.
(B) The reduced reproductive fitness of offspring from crosses between different species.
(C) The tendency of hybrids to show qualities superior to those of both parents.
(D) The high genetic uniformity observed in offspring produced through inbreeding.

10. Which of the following is a key characteristic of apoptosis?
(A) Programmed cell death without inflammation
(B) Uncontrolled cell lysis and inflammation
(C) Formation of scar tissue
(D) Rapid proliferation of cells

11. Consider the following statements regarding RNA processing:
1. Capping involves the addition of a 7-methylguanosine to the 5' end of the pre-mRNA.
2. Polyadenylation adds a tail of adenine nucleotides to the 3' end.
3. Splicing removes exons and joins introns together.

Which of the statements given above is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 only
(D) 1, 2 and 3

12. The fidelity of DNA replication is enhanced by the proofreading activity of DNA polymerase, which is its:
(A) 5' to 3' polymerase activity
(B) 3' to 5' exonuclease activity
(C) 5' to 3' exonuclease activity
(D) Endonuclease activity

13. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The genetic code is described as degenerate.
Reason (R): More than one codon can specify a single amino acid.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

14. The analysis of a Cot curve provides information about the:
(A) Total number of protein-coding genes present within a specific genome.
(B) The relative G-C content measured within a given double-stranded DNA sample.
(C) The overall rate of protein synthesis occurring within a living eukaryotic cell.
(D) Proportion of repetitive and unique DNA sequences in a genome.

15. What is the role of euchromatin in the regulation of gene expression in eukaryotes?
(A) Loosely packed chromatin associated with active gene transcription.
(B) Highly condensed chromatin that leads to permanent gene silencing.
(C) Chromatin responsible for centromere formation during cell division.
(D) Non-coding RNA sequences that regulate the efficiency of translation.

16. Which component is NOT part of the prokaryotic transcription initiation complex?
(A) RNA Polymerase core enzyme
(B) TATA-binding protein (TBP)
(C) Sigma factor
(D) Promoter DNA sequence

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17. In the context of protein synthesis, which of the following is a termination codon?
(A) AUG
(B) UAA
(C) UGG
(D) GUC

18. In situ hybridization is a technique used to:
(A) Localize specific DNA or RNA sequences within tissue sections.
(B) Sequence the entire functional genome of a multicellular organism.
(C) Amplify specific DNA sequences within a

controlled laboratory setting.
(D) Separate cellular proteins based on their molecular size and charge.

19. An oncogene is best described as a gene that:
(A) Encodes a specific protein used to suppress tumor formation.
(B) Is a gene involved in the pathway for programmed cell death.
(C) Has the potential to cause cancer when mutated or overexpressed.
(D) Is a gene that repairs DNA damage to maintain genomic stability.

20. Which of the following is a characteristic feature of the innate immune system?
(A) It involves the production of antibodies.
(B) It has a memory component for faster secondary responses.
(C) It relies on T-lymphocytes and B-lymphocytes.
(D) It provides a rapid, non-specific response to pathogens.

21. Arrange the following steps of DNA replication in the correct chronological order:
1. Binding of initiator proteins to the origin of replication.
2. Synthesis of RNA primers by primase.
3. Unwinding of the DNA double helix by helicase.
4. Joining of Okazaki fragments by DNA ligase.
5. Synthesis of leading and lagging strands by DNA polymerase III.

(A) 1, 3, 2, 5, 4
(B) 3, 1, 2, 5, 4
(C) 1, 2, 3, 5, 4
(D) 2, 1, 3, 4, 5

22. The term "tRNA identity" refers to the:
(A) Universal anticodon sequence found in all tRNA molecules.
(B) Set of features in a tRNA molecule that are recognized by the correct aminoacyl-tRNA synthetase.
(C) The 3' CCA sequence where the amino acid attaches.
(D) The total number of tRNA genes present in an organism's genome.

23. Which one of the following pairs is incorrectly matched?
(A) DNA Ligase - Joins DNA fragments
(B) Helicase - Unwinds DNA
(C) Topoisomerase - Relieves supercoiling
(D) Primase - Synthesizes DNA primers

24. Gene silencing can be achieved at the post-transcriptional level through a process involving:
(A) RNA interference (RNAi)
(B) Histone acetylation
(C) DNA methylation
(D) Promoter mutation

25. A key difference between bacterial transformation and conjugation is that:
(A) Transformation involves a viral vector, while conjugation does not.
(B) Transformation transfers both DNA and proteins, while conjugation only transfers DNA.
(C) Conjugation requires direct cell-to-cell contact, while transformation involves uptake of free DNA.
(D) Conjugation is a form of vertical gene transfer, while transformation is horizontal.

26. Which of the following is NOT a component of the adaptive immune system?
(A) Natural Killer (NK) cells
(B) B cells
(C) T cells
(D) Antibodies

27. Match List I (Process) with List II (Key Enzyme/Factor) and select the correct answer using the options given below:
List I: (Process)
P. DNA Replication
Q. Transcription
R. Translation
S. DNA Repair
List II: (Key Enzyme/Factor)
1. RNA Polymerase
2. Aminoacyl-tRNA Synthetase
3. DNA Polymerase III
4. DNA Photolyase
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

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28. In protein synthesis, the function of elongation factor Tu (EF-Tu) in prokaryotes is to:
(A) Catalyze the formation of the peptide bond.
(B) Bind and deliver the aminoacyl-tRNA to the A-site of the ribosome.
(C) Facilitate the translocation of the ribosome.
(D) Recognize the stop codon and terminate translation.

29. A frameshift mutation is caused by:
(A) The substitution of a single nucleotide.
(B) The chemical modification of a base, such as deamination.
(C) The insertion or deletion of nucleotides in a number not divisible by three.
(D) A change from a purine to a pyrimidine or vice versa.

30. The genetic basis of inbreeding depression is primarily attributed to:
(A) The increased frequency of beneficial dominant alleles in a population.
(B) The masking of deleterious recessive alleles in heterozygous individuals.
(C) The spontaneous creation of new and advantageous genetic mutations.
(D) Increased homozygosity exposing deleterious recessive alleles.

31. Consider the following statements about Z-DNA:
1. It is a right-handed double helix.
2. Its backbone follows a zigzag path.
3. It can be formed by sequences of alternating purines and pyrimidines.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

32. What is the role of restriction enzymes in generating a restriction map?
(A) To sequence the entire DNA fragment.
(B) To cut DNA at specific recognition sites, creating fragments of different sizes.
(C) To amplify the DNA fragment for better visualization.
(D) To join different DNA fragments together.

33. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Eukaryotic mRNAs undergo capping at the 5' end.
Reason (R): The 5' cap protects the mRNA from degradation by exonucleases and is essential for translation initiation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

34. RNA editing is a process that:
(A) Alters the nucleotide sequence of an RNA molecule after transcription.
(B) Removes introns from a pre-mRNA molecule.
(C) Adds a poly(A) tail to the 3' end of an mRNA.
(D) Attaches the 5' cap to the pre-mRNA.

35. The site on the ribosome where a new incoming aminoacyl-tRNA binds is the:
(A) P site (peptidyl site)
(B) E site (exit site)
(C) A site (aminoacyl site)
(D) T site (translocation site)

36. Protein sorting refers to the mechanism by which:
(A) Proteins are folded into their correct three-dimensional structures.
(B) Proteins are degraded after they have fulfilled their function.
(C) Proteins are modified by the addition of carbohydrate groups.
(D) Proteins are delivered to their correct destinations within or outside the cell.

37. Recombination in phages, such as lambda phage, can occur through:
(A) Random insertion into the host chromosome.
(B) Sexual reproduction between two phage particles.
(C) Site-specific recombination at att sites.
(D) Reverse transcription of the phage genome.

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38. Which statement correctly describes the exploitation of hybrid vigour in plant breeding?
(A) Continuous self-pollination to create genetically pure parental lines.
(B) Crossing inbred lines to produce F1 hybrids with superior traits.
(C) Increasing the level of homozygosity within a given plant population.
(D) Eliminating all existing genetic variation from a specific crop species.

39. The process of apoptosis is regulated by a family of proteases known as:
(A) Kinases
(B) Phosphatases
(C) Lipases
(D) Caspases

40. What is the defining characteristic of the adaptive immune response?
(A) It is characterized by specificity and memory.
(B) It is the first line of defense against pathogens.
(C) It is non-specific and acts broadly against all foreign substances.
(D) It primarily involves phagocytic cells like macrophages.

41. A multigene family is a collection of:
(A) Several genes that are all transcribed into a single, long mRNA.
(B) Genes that are located on different chromosomes but are functionally related.
(C) Similar genes that arose by duplication of a single ancestral gene.
(D) Genes that are only expressed during a specific developmental stage.

42. Arrange the following events in the process of bacterial conjugation in the correct sequence:
1. Formation of a mating bridge or pilus.
2. Transfer of a single strand of the F-plasmid.
3. Synthesis of a complementary strand in the recipient cell.
4. Physical contact between donor (F+) and recipient (F-) cells.

(A) 4, 1, 2, 3
(B) 1, 4, 2, 3
(C) 4, 2, 1, 3
(D) 2, 3, 4, 1

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43. Which of the following is NOT a feature of the genetic code?
(A) It is triplet.
(B) It is degenerate.
(C) It is nearly universal.
(D) It is overlapping.

44. Given below are two statements:
Statement I: The formation of the translation initiation complex in eukaryotes requires several initiation factors (eIFs).
Statement II: The 40S ribosomal subunit, along with initiation factors, binds to the 5' cap of the mRNA and scans for the first AUG codon.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

45. The "unit of replication" in DNA, also known as a replicon, typically contains:
(A) At least one promoter and one terminator sequence.
(B) Only the coding sequence for a single protein.
(C) An origin of replication and may have a terminus.
(D) A centromere and two telomeres.

46. Which of the following DNA repair mechanisms is most likely to repair pyrimidine dimers caused by UV radiation?
(A) Base Excision Repair (BER)
(B) Nucleotide Excision Repair (NER)
(C) Mismatch Repair (MMR)
(D) Direct Repair by DNA photolyase

47. Match List I (Translation Inhibitor) with List II (Mechanism of Action) and select the correct answer using the options given below:
List I: (Translation Inhibitor)
P. Tetracycline
Q. Chloramphenicol
R. Puromycin
S. Streptomycin
List II: (Mechanism of Action)
1. Causes premature chain termination

2. Inhibits peptidyl transferase activity on ribosomes
3. Prevents binding of aminoacyl-tRNA to the A-site
4. Causes misreading of mRNA and inhibits initiation

(A) P-1, Q-2, R-4, S-3
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-3, Q-1, R-4, S-2

48. Regulation of gene expression in eukaryotes by altering chromatin structure is often mediated by:
(A) RNA splicing machinery.
(B) Modification of histone proteins, such as acetylation and methylation.
(C) The synthesis of different sigma factors.
(D) The rate of ribosome translocation.

49. Which type of RNA acts as an adapter molecule in protein synthesis, matching codons in mRNA to specific amino acids?
(A) Ribosomal RNA (rRNA)
(B) Messenger RNA (mRNA)
(C) Transfer RNA (tRNA)
(D) Small nuclear RNA (snRNA)

50. Inbreeding depression in plant breeding can be overcome by:
(A) Continued self-pollination for many generations.
(B) Crossing the inbred line with a genetically different line (outcrossing).
(C) Exposing the plants to mutagens to increase genetic diversity.
(D) Using vegetative propagation methods.

51. Consider the following statements regarding the eukaryotic ribosome:
1. It is an 80S ribosome composed of 60S and 40S subunits.
2. The large subunit catalyzes peptide bond formation.
3. The small subunit is primarily responsible for binding mRNA.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

52. The process where cells engulf large particles or other cells is part of the innate immune response and is called:
(A) Apoptosis
(B) Phagocytosis
(C) Pinocytosis
(D) Exocytosis

53. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In eukaryotes, a single primary transcript (pre-mRNA) can be spliced in different ways to yield multiple mature mRNAs.
Reason (R): Alternative splicing significantly increases the protein-coding capacity of a genome.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

54. The replication fork is a structure that forms:
(A) At the end of a chromosome, known as the telomere.
(B) Within the nucleus during the G2 phase of the cell cycle.
(C) Where the DNA double helix is unwound to create two single-stranded templates.
(D) After DNA replication is complete, to separate the two daughter molecules.

55. In the context of bacterial genetics, Hfr (high frequency of recombination) cells are bacterial cells that:
(A) Contain multiple F plasmids in their cytoplasm.
(B) Are unable to participate in conjugation.
(C) Have the F factor integrated into their chromosome.
(D) Have lost the F factor and become F- cells.

56. The structure and function of which type of RNA is primarily related to the splicing of pre-mRNA in eukaryotes?
(A) Transfer RNA (tRNA)
(B) MicroRNA (miRNA)
(C) Small nuclear RNA (snRNA)
(D) Ribosomal RNA (rRNA)

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57. The addition of a poly(A) tail to a eukaryotic pre-mRNA is catalyzed by the enzyme:
(A) RNA Polymerase II
(B) Poly(A) Polymerase
(C) Guanylyl transferase
(D) Primase

58. Which of the following is an example of a post-translational modification that targets a protein for degradation by the proteasome?
(A) Phosphorylation
(B) Acetylation
(C) Glycosylation
(D) Polyubiquitination

59. In the context of cancer, proto-oncogenes are:
(A) Genes that have been introduced into a cell by a virus.
(B) Normal cellular genes that regulate cell growth and division.
(C) Genes that are permanently inactivated and cannot cause cancer.
(D) Genes that exclusively function to induce apoptosis.

60. Which of the following pairs concerning RNA types and their function is correctly matched?
(A) rRNA - Carries the genetic code from the nucleus to the ribosome.
(B) snRNA - Component of the spliceosome for intron removal.
(C) tRNA - Acts as a structural and catalytic component of the ribosome.
(D) mRNA - Translates the genetic code into a sequence of amino acids.

61. Recombinant DNA technology most critically relies on the ability of which two types of enzymes?
(A) DNA polymerases and helicases
(B) Restriction enzymes and DNA ligases
(C) Topoisomerases and primases
(D) RNA polymerases and reverse transcriptases

62. Arrange the major steps of protein synthesis in their correct sequence:
1. Elongation of the polypeptide chain.
2. Activation of amino acids and attachment to tRNA.
3. Termination of protein synthesis.
4. Formation of the translation initiation complex.

(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 2, 1, 4, 3
(D) 4, 1, 2, 3

63. The phenomenon where the presence of glucose inhibits the expression of genes in the lac operon, even if lactose is present, is known as:
(A) Attenuation
(B) Catabolite repression
(C) Negative feedback
(D) Induction

64. Given below are two statements:
Statement I: The fidelity of DNA replication is much lower than the fidelity of transcription.
Statement II: Errors in DNA replication are heritable and can lead to permanent mutations, while errors in transcription are transient.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

65. Which of the following is the most accurate description of a gene mutation?
(A) A change in the number of chromosomes in a cell.
(B) A permanent alteration in the DNA sequence of a gene.
(C) The process of exchanging genetic material between homologous chromosomes.
(D) The temporary inactivation of a gene through methylation.

66. In plant breeding, in situ hybridization would be most useful for:
(A) Determining the chromosomal location of a specific gene.
(B) Creating a hybrid plant with increased yield.
(C) Measuring the rate of photosynthesis in a leaf.
(D) Analyzing the protein content of seeds.

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complex eukaryotic gene.
(C) Gene duplication followed by divergence in sequence and function.
(D) Horizontal transfer of functional genes from different biological species.

104. Which of the following is a key difference between eukaryotic and prokaryotic RNA polymerases?
(A) Prokaryotic polymerases synthesize RNA in a 3' to 5' direction.
(B) Eukaryotes have multiple specialized RNA polymerases, while prokaryotes have one main type.
(C) Only prokaryotic RNA polymerase requires a promoter to initiate transcription.
(D) Eukaryotic RNA polymerase does not require transcription factors.

105. Puromycin is a translation inhibitor because it:
(A) Resembles an aminoacyl-tRNA and causes premature chain termination.
(B) Blocks the translocation step of the ribosome.
(C) Prevents the binding of mRNA to the small ribosomal subunit.
(D) Inhibits the peptidyl transferase activity of the large ribosomal subunit.

106. Match List I (Immune System Component) with List II (Primary Function) and select the correct answer using the options given below:
List I: (Immune System Component)
P. B-Lymphocyte
Q. Cytotoxic T-Lymphocyte (CTL)
R. Helper T-Lymphocyte
S. Macrophage
List II: (Primary Function)
1. Phagocytosis and antigen presentation
2. Produces antibodies
3. Kills infected host cells
4. Activates other immune cells like B cells and CTLs
(A) P-1, Q-4, R-3, S-2
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-2, R-4, S-1

107. The regulation of the trp operon in E. coli involves both a repressor protein and a process called attenuation. Attenuation fine-tunes transcription based on:
(A) The concentration of glucose in the cell.
(B) The availability of charged tryptophan tRNA.
(C) The presence of a viral infection.
(D) The level of DNA damage in the cell.

108. Given below are two statements:
Statement I: Protein sorting ensures that newly synthesized polypeptides are delivered to the correct suboptimal or extracellular location.
Statement II: Signal sequences, which are short stretches of amino acids, often act as "zip codes" to direct proteins to their destinations.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

109. Which characteristic of Z-DNA makes it structurally distinct from B-DNA?
(A) It is a single-stranded helix.
(B) It is a left-handed helix with a zigzagging sugar-phosphate backbone.
(C) It is a right-handed helix with 12 base pairs per turn.
(D) It lacks hydrogen bonding between base pairs.

110. A nonsense mutation is a type of point mutation that results in:
(A) A codon that specifies an amino acid being changed to a stop codon.
(B) A codon specifying a different amino acid.
(C) The insertion of an extra nucleotide.
(D) No change in the amino acid sequence due to code degeneracy.

111. Consider the following statements about DNA ligase:
1. It forms phosphodiester bonds between adjacent nucleotides.
2. It is essential for joining Okazaki fragments on the lagging strand during replication.
3. It can join DNA fragments with either blunt or sticky ends.

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75. The exploitation of hybrid vigour is a cornerstone of modern agriculture because F1 hybrids often exhibit:
(A) Greater genetic diversity within the F1 generation.
(B) High levels of inbreeding depression.
(C) Uniformity and increased yield compared to parental lines.
(D) Recessive traits not seen in either parent.

76. Tumor suppressor genes, such as p53, function to:
(A) Inhibit cell cycle progression or induce apoptosis in response to DNA damage.
(B) Promote cell division and proliferation.
(C) Mutate into oncogenes upon exposure to carcinogens.
(D) Encode growth factors that stimulate angiogenesis.

77. RNA transport from the nucleus to the cytoplasm is a regulated process that primarily involves:
(A) Passive diffusion of molecules through the lipid nuclear membrane.
(B) Encapsulation in transport vesicles that fuse with the membrane.
(C) Movement along microtubule tracks that penetrate the nuclear area.
(D) Selective export via nuclear pores using specific signal receptors.

78. What is the role of initiation factors (IFs) in prokaryotic translation?
(A) They help assemble the 70S ribosome at the start codon of the mRNA.
(B) They catalyze the formation of peptide bonds.
(C) They recognize stop codons and cause the release of the polypeptide chain.
(D) They are responsible for charging tRNAs with amino acids.

79. The genetic basis of heterosis is often explained by the dominance hypothesis, which states that:
(A) Accumulating more new mutations than traditional inbred lines.
(B) Masking deleterious recessive alleles with functional dominant ones.
(C) Providing a heterozygote advantage through overdominance at loci.
(D) Inheriting two different alleles that are intrinsically superior.

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80. Which of the following is a component of the innate immune system that acts as a chemical barrier?
(A) Lysozyme in tears and saliva
(B) Skin epidermis
(C) Mucous membranes
(D) T-lymphocytes

81. Arrange the following eukaryotic RNA polymerases according to the primary type of RNA they transcribe:
1. RNA Polymerase I
2. RNA Polymerase II
3. RNA Polymerase III
(A) I-tRNA, II-mRNA, III-rRNA
(B) I-rRNA, II-mRNA, III-tRNA and 5S rRNA
(C) I-mRNA, II-rRNA, III-tRNA
(D) I-rRNA, II-tRNA, III-mRNA

82. The 'A' form of DNA is different from the 'B' form in that it is:
(A) Shorter and wider with a tilted base pair orientation.
(B) Left-handed and more elongated.
(C) The most common physiological form of DNA.
(D) Found only in viral genomes.

83. Which statement regarding transcription termination in prokaryotes is correct?
(A) All transcription termination is dependent on the Rho protein.
(B) Rho-independent termination involves the formation of a stable hairpin structure in the nascent RNA.
(C) Termination always occurs at a fixed distance from the start codon.
(D) Eukaryotic termination signals are recognized by prokaryotic RNA polymerase.

84. In the context of the genetic code, what does it mean for an amino acid to be specified by a "codon"?
(A) A sequence of three nucleotides in tRNA.
(B) A sequence of three nucleotides in mRNA.
(C) A sequence of three amino acids in a protein.
(D) A single nucleotide in DNA.

85. Which of the following is an example of an oncogene?
(A) p53
(B) BRCA1
(C) Ras
(D) Rb

86. Match List I (Cellular Process) with List II (Primary Location in Eukaryotes) and select the correct answer using the options given below:
List I: (Cellular Process)
P. Transcription
Q. Translation (of most proteins)
R. Splicing
S. DNA Replication
List II: (Primary Location in Eukaryotes)
1. Cytoplasm
2. Nucleus
3. Nucleus
4. Nucleus
(A) P-2, Q-1, R-2, S-2
(B) P-1, Q-2, R-1, S-2
(C) P-2, Q-1, R-1, S-1
(D) P-2, Q-2, R-2, S-1

87. Which of the following is NOT a mechanism of DNA damage?
(A) Depurination
(B) Deamination
(C) Formation of thymine dimers by UV light
(D) Accurate proofreading by DNA polymerase

88. Given below are two statements:
Statement I: Transformation is the genetic alteration of a cell resulting from the direct uptake and incorporation of exogenous genetic material from its surroundings.
Statement II: Conjugation is the process by which foreign DNA is introduced into a cell by a virus.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

89. Apoptosis is a fundamental process in:
(A) Normal development and tissue homeostasis.
(B) Inflammatory responses to infection.
(C) Uncontrolled cancer growth.
(D) The generation of scar tissue after injury.

90. The concept that one gene can code for more than one protein is best explained by:
(A) The C-value paradox
(B) Alternative splicing
(C) Gene silencing
(D) Inbreeding depression

91. Consider the following statements regarding the elongation phase of translation:
1. An aminoacyl-tRNA binds to the A site of the ribosome.
2. A peptide bond is formed between the amino acid in the A site and the growing polypeptide in the P site.
3. The ribosome translocates one codon down the mRNA, a step that requires elongation factors and GTP.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

92. The major histocompatibility complex (MHC) molecules are central to the adaptive immune system because they:
(A) Directly neutralize pathogens by binding to their surface.
(B) Present processed antigens to T cells.
(C) Are the primary component of complement proteins.
(D) Function as phagocytic receptors on macrophages.

93. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Z-DNA has a left-handed helical conformation.
Reason (R): This conformation is favored by alternating purine-pyrimidine sequences, such as poly(GC), under conditions of high salt concentration.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct

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explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

94. Base excision repair (BER) is a DNA repair mechanism that typically corrects damage to:
(A) Large segments of DNA containing multiple damaged bases.
(B) A single damaged or incorrect base, such as one that has been deaminated or oxidized.
(C) Double-strand breaks in the DNA backbone.
(D) Mismatches that occur during DNA replication.

95. The genetic basis of inbreeding often leads to a decrease in fitness known as inbreeding depression. This is best described as a consequence of:
(A) Increased levels of heterozygosity across the entire genome.
(B) Expression of deleterious recessive alleles in homozygotes.
(C) The introduction of new and beneficial genetic mutations.
(D) An enhanced ability to adapt to rapid environmental changes.

96. Which of the following describes the role of a transcription repressor?
(A) It binds to a silencer or operator sequence to block or reduce transcription.
(B) It binds to an enhancer sequence to increase the rate of transcription.
(C) It modifies histones to create a more open chromatin structure.
(D) It is a part of the core RNA polymerase enzyme.

97. During the processing of eukaryotic mRNA, what is the function of the spliceosome?
(A) To add the 5' cap.
(B) To add the 3' poly(A) tail.
(C) To remove introns and join exons.
(D) To transport the mRNA out of the nucleus.

98. The "charging" of a tRNA molecule involves the covalent attachment of:
(A) A specific amino acid to its 3' end by an aminoacyl-tRNA synthetase.
(B) A phosphate group to its 5' end.
(C) An anticodon loop to the ribosome.
(D) A methyl group to one of its bases.

99. Translation proofreading, which enhances the fidelity of protein synthesis, is primarily carried out by:
(A) The mRNA codon sequence.
(B) The aminoacyl-tRNA synthetase, which has an editing site.
(C) The ribosome itself.
(D) Elongation factor G (EF-G).

100. In plant breeding, heterosis is most pronounced in the:
(A) P1 and P2 parental inbred lines.
(B) F2 generation produced by selfing the F1 hybrids.
(C) Backcross generation.
(D) F1 generation resulting from a cross between two diverse parents.

101. Arrange the following events of eukaryotic transcription initiation in the correct order:
1. Binding of TFIID (containing TBP) to the TATA box.
2. Recruitment of RNA Polymerase II and other general transcription factors to form the pre-initiation complex.
3. Phosphorylation of the C-terminal domain (CTD) of RNA Polymerase II.
4. Unwinding of the DNA at the promoter to form the transcription bubble.

(A) 1, 2, 4, 3
(B) 2, 1, 4, 3
(C) 1, 4, 2, 3
(D) 4, 1, 2, 3

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102. What does a high $C_0t_{1/2}$ value on a Cot curve signify?
(A) The genome contains a high proportion of rapidly reassociating repetitive DNA.
(B) The genome has a high proportion of unique, non-repetitive DNA sequences.
(C) The genome is very small and lacks complexity.
(D) The DNA sample has a high G-C content.

103. Which is the most appropriate description of a multigene family's evolution?
(A) Convergence of unrelated genes to perform a similar biological function.
(B) Alternative splicing of a single large and

67. Which of the following statements about the role of the sigma factor in bacterial transcription is correct?
(A) Acts as the primary factor responsible for the termination of transcription.
(B) Provides a proofreading function to ensure overall transcription accuracy.
(C) Recognizes the promoter to help RNA polymerase bind the start site.
(D) Synthesizes the RNA transcript directly in a 5' to 3' direction.

68. Match List I (Concept) with List II (Description) and select the correct answer using the options given below:
List I: (Concept)
P. C-value paradox
Q. Cot curve
R. Restriction map
S. Multigene family
List II: (Description)
1. A diagram showing the location of cleavage sites for specific endonucleases on a DNA molecule.
2. A group of genes with similar sequences and functions, derived from a common ancestor.
3. The lack of correlation between genome size and organismal complexity.
4. A plot used to measure the complexity and repetitiveness of a genome.
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

69. The "wobble" hypothesis, proposed by Francis Crick, relates to the:
(A) Instability of the DNA double helix.
(B) Flexible pairing between the third base of a codon and the first base of its anticodon.
(C) Movement of the ribosome along the mRNA during translocation.
(D) Proofreading mechanism of DNA polymerase.

70. The function of transcription activators is to:
(A) Directly methylate DNA to silence gene expression.
(B) Bind to enhancer sequences and facilitate the assembly of the transcription machinery.
(C) Unwind the DNA double helix at the replication fork.
(D) Degrade mRNA molecules after translation is complete.

71. Consider the following statements about protein targeting to organelles:
1. Proteins destined for the endoplasmic reticulum often have a signal peptide at their N-terminus.
2. Proteins targeted to the nucleus have a nuclear localization signal (NLS).
3. All proteins are synthesized on free ribosomes and then sorted to their final destination.
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

72. In a prokaryotic cell, which RNA polymerase is responsible for synthesizing all types of RNA (mRNA, tRNA, rRNA)?
(A) RNA Polymerase I
(B) RNA Polymerase II
(C) A single type of RNA Polymerase
(D) RNA Polymerase III

73. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Conjugation in bacteria allows for the transfer of genetic material.
Reason (R): This process requires a physical connection, often a pilus, between a donor and a recipient cell.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

74. A transition mutation is a point mutation that involves the replacement of:
(A) A purine with another purine, or a pyrimidine with another pyrimidine.
(B) A purine with a pyrimidine.
(C) A pyrimidine with a purine.
(D) An amino acid with a stop codon.

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Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

112. The role of Caspase-9 in the intrinsic pathway of apoptosis is to act as:
(A) An initiator caspase, activated by the apoptosome.
(B) An anti-apoptotic protein.
(C) An executioner caspase that cleaves cellular substrates.
(D) A receptor on the cell surface.

113. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Inbreeding in a population leads to an increase in the frequency of homozygotes.
Reason (R): This increased homozygosity can lead to inbreeding depression if deleterious recessive alleles are present in the population's gene pool.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

114. The unit of replication, or replicon, in prokaryotic DNA is characterized by having:
(A) Multiple origins of replication per chromosome.
(B) A single origin of replication for the entire circular chromosome.
(C) Telomeres at each end to protect from degradation.
(D) A complex system of histones for packaging.

115. RNA editing by deamination can change a cytosine (C) residue in an mRNA transcript to:
(A) Adenosine (A)
(B) Guanine (G)
(C) Uracil (U)
(D) Thymine (T)

116. The function of elongation factor G (EF-G) in prokaryotic translation is to:
(A) Deliver the aminoacyl-tRNA to the A-site.
(B) Promote the translocation of the ribosome along the mRNA.
(C) Catalyze the peptidyl transferase reaction.
(D) Recognize the stop codon and terminate translation.

117. Gene silencing by RNA interference (RNAi) involves which of the following molecules?
(A) Using repressor proteins that bind directly to a specific DNA sequence.
(B) Using siRNAs or miRNAs to guide protein complexes to target mRNA.
(C) Using methyltransferase enzymes to add methyl groups to CpG islands.
(D) Using histone deacetylases to condense the overall chromatin structure.

118. Which part of the adaptive immune system is primarily responsible for producing antibodies?
(A) B cells (or plasma cells)
(B) Cytotoxic T cells
(C) Natural Killer cells
(D) Macrophages

119. What is the main purpose of a restriction map?
(A) To provide the complete nucleotide sequence of a DNA molecule.
(B) To identify all the genes present on a chromosome.
(C) To show the linear order and distance between cleavage sites for different restriction enzymes on a DNA segment.
(D) To measure the rate of transcription of a specific gene.

120. In the formation of the eukaryotic translation initiation complex, the ribosome typically starts translation at:
(A) The first nucleotide of the mRNA.
(B) Any AUG codon on the mRNA.
(C) A specific Shine-Dalgarno sequence.
(D) The first AUG codon it encounters after the 5' cap.

121. What is the fundamental difference between genetic transformation and transduction in bacteria?
(A) Transformation involves DNA transfer via a pilus, while transduction does not.
(B) Transformation is the uptake of naked DNA, while transduction involves a bacteriophage

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vector.
(C) Transduction is the uptake of naked DNA, while transformation involves a bacteriophage vector.
(D) Transformation occurs only in Gram-positive bacteria, and transduction only in Gram-negative.

122. Arrange the key steps in the base excision repair (BER) pathway in the correct order:
1. A DNA glycosylase recognizes and removes the damaged base.
2. An AP endonuclease cuts the phosphodiester backbone at the AP site.
3. DNA polymerase fills the gap.
4. DNA ligase seals the nick.

(A) 1, 2, 3, 4
(B) 2, 1, 3, 4
(C) 1, 3, 2, 4
(D) 3, 1, 2, 4

123. The overdominance hypothesis for heterosis suggests that:
(A) Superior fitness of the heterozygote over both homozygous genotypes.
(B) Masking of harmful recessive alleles by functional dominant alleles.
(C) Epistatic interactions between different loci leading to enhanced traits.
(D) Lower mutation rates in hybrid lines compared to inbred parental lines.

124. Which of the following is NOT a characteristic of the adaptive immune system?
(A) Specificity
(B) Immediate response upon first exposure
(C) Memory
(D) Self/non-self discrimination

125. Which one of the following statements about gene mutation is incorrect?
(A) A silent mutation results in no change to the amino acid sequence.
(B) A missense mutation results in the substitution of one amino acid for another.
(C) A frameshift mutation always results in a single amino acid change.
(D) A nonsense mutation converts a codon for an amino acid into a stop codon.

126. Match List I (Process) with List II (Associated Terminology) and select the correct answer using the options given below:
List I: (Process)
P. DNA Replication
Q. Transcription
R. Translation
S. Gene Regulation
List II: (Associated Terminology)
1. Codon, Anticodon
2. Okazaki fragment, Replicon
3. Promoter, Terminator
4. Operon, Enhancer

(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-1, S-2

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127. The fidelity of DNA replication refers to:
(A) The ability of the replication machinery to accurately copy the DNA template with very few errors.
(B) The speed at which DNA is synthesized.
(C) The process of unwinding the DNA double helix.
(D) The number of origins of replication used during S phase.

128. Given below are two statements:
Statement I: Recombinant DNA is an artificial DNA molecule created by joining DNA from different sources.
Statement II: The creation of recombinant DNA is a natural process that occurs during meiosis.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

129. The formation of the transcription initiation complex in eukaryotes is a complex process that starts with the binding of which factor to the promoter?
(A) RNA Polymerase II
(B) TFIID, which contains the TATA-binding protein (TBP)
(C) TFIIH, which has helicase activity

(D) The Mediator complex

130. The structure of tRNA is critical for its function. The part of the tRNA that base-pairs with the codon on the mRNA is the:
(A) 3' acceptor stem
(B) D loop
(C) Anticodon loop
(D) TΨC loop

131. Consider the following statements regarding post-translational modification of proteins:
1. Phosphorylation can activate or deactivate an enzyme.
2. Glycosylation is the addition of sugar moieties and is common for secreted proteins.
3. Acetylation of histones is considered a post-translational modification.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

132. The Bcl-2 family of proteins plays a crucial role in regulating apoptosis by:
(A) Directly cleaving cellular substrates to execute cell death.
(B) Containing both pro-apoptotic and anti-apoptotic members that control mitochondrial outer membrane permeabilization.
(C) Acting as cell surface receptors that bind death ligands.
(D) Phosphorylating and activating initiator caspases.

133. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In eukaryotes, genes located in euchromatin are generally more actively transcribed than those in heterochromatin.
Reason (R): Euchromatin has a more open, decondensed structure, making the DNA more accessible to transcription factors and RNA polymerase.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

134. Which enzyme is responsible for removing the RNA primers laid down during DNA replication and replacing them with DNA nucleotides?
(A) DNA Polymerase III
(B) DNA Polymerase I (in prokaryotes)
(C) DNA Ligase
(D) Helicase

135. The concept of "tRNA identity" is crucial for the fidelity of translation. It refers to the specific molecular features of a tRNA molecule recognized by its corresponding:
(A) Aminoacyl-tRNA synthetase
(B) Ribosome
(C) mRNA codon
(D) Elongation factor

136. Which of the following is a mechanism for regulating gene expression at the translational level?
(A) Alternative splicing of pre-mRNA.
(B) Regulation of translation initiation by phosphorylation of initiation factors (e.g., eIF2).
(C) Methylation of DNA in the promoter region.
(D) Histone acetylation to open up chromatin.

137. Conjugation between an Hfr bacterium and an F- bacterium typically results in the:
(A) Recipient cell becoming an Hfr cell.
(B) Transfer of a portion of the Hfr cell's chromosome, but the recipient usually remains F-.
(C) Recipient cell becoming an F+ cell.
(D) Complete transfer of the Hfr chromosome and the F factor.

138. The primary difference between innate and adaptive immunity lies in:
(A) The types of pathogens they can target.
(B) The speed and specificity of the response.
(C) The location in the body where they operate.
(D) The involvement of cellular versus humoral components.

139. A Cot curve is generated by measuring the rate at which:

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(A) DNA is replicated.
(B) DNA is transcribed into RNA.
(C) Single-stranded DNA reassociates to form double-stranded DNA.
(D) Proteins are synthesized from an mRNA template.

140. Which of the following best describes the function of a telomere?
(A) Specialized structure at the end of a chromosome that prevents degradation.
(B) Chromosomal region that acts as the primary origin of DNA replication.
(C) Binding site for transcription factors that regulate gene expression.
(D) Point of attachment for spindle fibers during the process of mitosis.

141. The genetic code is said to be "non-overlapping," which means that:
(A) Each codon specifies only one amino acid.
(B) The code is the same in almost all organisms.
(C) Different codons can specify the same amino acid.
(D) Each nucleotide in the mRNA is part of only one codon.

142. Arrange the general flow of genetic information as described by the central dogma, including its extension:
1. Translation
2. Transcription
3. Reverse Transcription
4. Replication

(A) 4, 3, 2, 1
(B) 4, 2, 1, 3
(C) 3, 4, 2, 1
(D) 4, 2, 3, 1

143. Which of the following is a primary function of ribosomal RNA (rRNA)?
(A) To carry amino acids to the ribosome.
(B) To serve as the template for protein synthesis.
(C) To act as a structural and catalytic component of the ribosome.
(D) To regulate gene expression by binding to mRNA.

144. In the context of cancer, metastasis refers to:
(A) The initial formation of a tumor.
(B) The process of programmed cell death.
(C) The uncontrolled proliferation of cells at the original site.
(D) The spread of cancer cells from the primary tumor to new locations in the body.

145. In situ hybridization is a powerful technique for:
(A) Determining the expression pattern of a specific gene within a tissue.
(B) Amplifying trace amounts of DNA.
(C) Separating proteins based on their isoelectric point.
(D) Creating a genomic library.

146. Match List I (Regulatory Mechanism) with List II (Level of Control) and select the correct answer using the options given below:
List I: (Regulatory Mechanism)
P. DNA Methylation
Q. Alternative Splicing
R. miRNA-mediated silencing
S. Phosphorylation of eIF2
List II: (Level of Control)
1. Translational control
2. Post-transcriptional control (RNA processing)
3. Transcriptional control (epigenetic)
4. Post-transcriptional control (RNA degradation/silencing)

(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-3, R-1, S-4

147. What is the role of topoisomerases in DNA replication?
(A) To synthesize RNA primers.
(B) To join Okazaki fragments.
(C) To relieve the torsional stress and supercoiling created by DNA unwinding.
(D) To unwind the DNA double helix.

148. Given below are two statements:
Statement I: All gene mutations are harmful to the organism.
Statement II: A silent mutation changes the DNA sequence, but the resulting mRNA codon still codes for the same amino acid, causing no change in the protein.
(A) Both Statement I and Statement II are correct.

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(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

149. The termination of translation occurs when the ribosome encounters a stop codon on the mRNA, which is then recognized by:
(A) A special terminator tRNA.
(B) The elongation factor EF-G.
(C) A protein called a release factor.
(D) The small ribosomal subunit.

150. Which of the following is a characteristic of B-form DNA?
(A) Left-handed helix
(B) Approximately 10.5 base pairs per turn
(C) Major and minor grooves are of similar size
(D) Base pairs are strongly tilted relative to the helix axis

151. Consider the following statements about RNA capping:
1. It involves the addition of a modified guanine nucleotide to the 5' end of the transcript.
2. The linkage formed is an unusual 5'-5' triphosphate bridge.
3. Capping occurs after the transcript has been fully synthesized and released.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

152. The genetic basis of hybrid vigour (heterosis) is complex, but the "dominance hypothesis" suggests that its effects arise from:
(A) Superior fitness of heterozygous loci compared to either homozygous state.
(B) Masking of deleterious recessive alleles from parents in the hybrid.
(C) Spontaneous generation of beneficial mutations within the F1 hybrid.
(D) Increased rates of chromosomal crossing over during the meiotic process.

153. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Nuclear DNA content, or C-value, does not directly correlate with the complexity of an organism.
Reason (R): Eukaryotic genomes contain large amounts of non-coding and repetitive DNA, which contribute to genome size but not necessarily to the number of functional genes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

154. A key step in the activation of the adaptive immune response is:
(A) The presentation of antigen by an antigen-presenting cell (APC) to a helper T cell.
(B) The release of histamine from mast cells.
(C) The phagocytosis of a pathogen by a neutrophil.
(D) The formation of the membrane attack complex by complement proteins.

155. In the regulation of the lac operon, what is the role of allolactose?
(A) It acts as a co-repressor, binding to the repressor protein and activating it.
(B) It acts as an inducer, binding to the repressor protein and inactivating it.
(C) It binds to the operator region, blocking transcription.
(D) It is the primary energy source when glucose is absent.

156. The structure formed by the association of snRNAs and proteins, which is central to pre-mRNA splicing, is called the:
(A) Ribosome
(B) Proteasome
(C) Spliceosome
(D) Nucleosome

157. A signal peptide on a newly synthesized protein functions to:
(A) Target the protein for degradation.
(B) Direct the ribosome-mRNA-polypeptide complex to the endoplasmic reticulum.

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(C) Promote the correct folding of the protein in the cytoplasm.
(D) Catalyze the formation of disulfide bonds.

158. Recombination in bacteriophages allows them to:
(A) Replicate their DNA without a host cell.
(B) Generate new combinations of genes, contributing to phage evolution.
(C) Switch from a lytic to a lysogenic cycle.
(D) Infect plant cells as well as bacteria.

159. Cancer can be caused by mutations in tumor suppressor genes. How many alleles of a typical tumor suppressor gene must usually be inactivated to lead to a loss of function?
(A) Only one allele (dominant negative effect)
(B) Both alleles
(C) Three or more alleles
(D) The number varies and is irrelevant

160. Which of the following best describes the role of DNA ligase in molecular cloning?
(A) To cut the vector and the DNA insert at specific sites.
(B) To form a permanent phosphodiester bond between the DNA insert and the vector.
(C) To amplify the amount of recombinant DNA.
(D) To introduce the recombinant plasmid into the host cell.

161. The process of RNA transport from the nucleus to the cytoplasm is selective and is mediated by:
(A) Simple and passive diffusion across the lipid nuclear envelope.
(B) Transport within vesicles that fuse with the nuclear membrane.
(C) Selective export of mature mRNAs via the nuclear pore complex.
(D) Direct passage through channels found in the nuclear lamina.

162. What is the final step in both prokaryotic and eukaryotic translation?
(A) A release factor binds to the stop codon in the A site, leading to hydrolysis of the polypeptide from the tRNA.
(B) The ribosome dissociates into its large and small subunits.
(C) The last tRNA is ejected from the E site.
(D) The mRNA is immediately degraded.

163. The genetic basis of inbreeding is the increase of homozygosity. What is the most direct consequence of this for a population?
(A) An increase in overall genetic diversity.
(B) An increase in the expression of recessive traits, both beneficial and deleterious.
(C) A decrease in the rate of mutation.
(D) An immediate increase in fitness, known as inbreeding vigour.

164. A key feature of the innate immune system is the use of pattern recognition receptors (PRRs), such as Toll-like receptors (TLRs). What do these receptors recognize?
(A) Specific antigenic sequences from a single unique pathogen strain.
(B) Host antibodies that have bound to the surface of invading pathogens.
(C) Conserved structures on pathogens like flagellin or lipopolysaccharide.
(D) Self-antigens recognized to prevent the development of autoimmunity.

165. Which of the following statements about transcription in prokaryotes is INCORRECT?
(A) Transcription and translation can occur simultaneously.
(B) It requires a single RNA polymerase for all genes.
(C) The sigma factor is required for termination.
(D) It is initiated at a promoter sequence.

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166. Match List I (Enzyme) with List II (Function in DNA Replication/Repair) and select the correct answer using the options given below:
List I: (Enzyme)
P. DNA Polymerase I
Q. Helicase
R. DNA Ligase
S. Primase
List II: (Function in DNA Replication/Repair)
1. Unwinds the DNA double helix
2. Synthesizes a short RNA primer
3. Joins DNA fragments by forming phosphodiester bonds
4. Removes RNA primers and fills in the gaps with DNA
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-3, S-2

(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-3, S-4

167. During elongation in protein synthesis, the ribosome translocates along the mRNA in which direction?
(A) 3' to 5' direction
(B) 5' to 3' direction
(C) In both directions from the start codon
(D) The ribosome is stationary while the mRNA moves

168. Given below are two statements:
Statement I: Apoptosis is a form of programmed cell death that is essential for normal development.
Statement II: Necrosis is a form of traumatic cell death that results from acute cellular injury and typically elicits an inflammatory response.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

169. What is the role of transcription activators and repressors in eukaryotes?
(A) They are DNA-binding proteins that modulate the rate of transcription initiation.
(B) They are integral parts of the RNA polymerase II enzyme.
(C) They are responsible for processing the pre-mRNA transcript.
(D) They guide the mRNA out of the nucleus to the cytoplasm.

170. Which of the following is NOT a form of DNA?
(A) A-DNA
(B) B-DNA
(C) Z-DNA
(D) Y-DNA

171. Consider the following statements about recombinant DNA:
1. It involves the use of restriction enzymes to cut DNA.
2. It requires a vector, such as a plasmid, to carry the foreign DNA into a host cell.
3. DNA ligase is used to join the DNA fragments.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

172. The C-value paradox is the observation that:
(A) DNA content is not always proportional to the number of protein-coding genes.
(B) Organismal complexity is not correlated with genome size.
(C) The G-C content varies widely between species.
(D) Chromosome number is not an indicator of organismal complexity.

173. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The genetic code is universal.
Reason (R): With very few exceptions, the same codons specify the same amino acids in all organisms from bacteria to humans.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

174. The process by which introns are removed from pre-mRNA is called:
(A) Polyadenylation
(B) Splicing
(C) Capping
(D) Editing

175. The formation of the 70S initiation complex in prokaryotic protein synthesis involves the Shine-Dalgarno sequence on the mRNA binding to a complementary sequence on the:
(A) 23S rRNA of the large subunit
(B) Initiator tRNA
(C) 16S rRNA of the small subunit
(D) Initiation Factor 3 (IF3)

176. Protein sorting to the mitochondrial matrix requires:
(A) A C-terminal signal sequence.

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(D) A consequence of reproduction through asexual or vegetative means.

196. The main catalytic activity of the ribosome (peptide bond formation) is carried out by:
(A) The mRNA template.
(B) The proteins in the large ribosomal subunit.
(C) The ribosomal RNA (rRNA) in the large subunit.
(D) The aminoacyl-tRNA synthetase enzyme.

197. Which of the following repair systems corrects errors made during DNA replication that have been missed by the polymerase's proofreading function?
(A) Base Excision Repair (BER)
(B) Nucleotide Excision Repair (NER)
(C) Mismatch Repair (MMR)
(D) Photoreactivation

198. The structure and function of different types of RNA are diverse. Which RNA type is directly translated into protein?
(A) rRNA
(B) tRNA
(C) mRNA
(D) snRNA

199. What are caspases?
(A) A family of proteins that promote cell survival.
(B) A family of proteases that are key mediators of apoptosis.
(C) Cell surface receptors that bind growth factors.
(D) Enzymes that repair damaged DNA.

200. Which component of the immune system provides a non-specific, immediate defense against pathogens?
(A) The innate immune system
(B) The adaptive immune system
(C) B-lymphocytes
(D) Memory T-cells

201. Which of the following is a characteristic of A-form DNA?
(A) It is wider and shorter helix than B-DNA.
(B) It is left-handed.
(C) It is the most common form in physiological conditions.
(D) It has 12 base pairs per turn.

202. The role of elongation factors in protein synthesis is to:
(A) Facilitate the binding of aminoacyl-tRNA, translocation, and other steps of polypeptide chain elongation.
(B) Initiate the process of translation.
(C) Terminate translation at a stop codon.
(D) Ensure correct protein folding.

203. Which of the following is a translation inhibitor that works by binding to the 30S ribosomal subunit and preventing the attachment of aminoacyl-tRNA in prokaryotes?
(A) Chloramphenicol
(B) Puromycin
(C) Erythromycin
(D) Tetracycline

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204. The phenomenon of "RNA editing" refers to:
(A) The post-transcriptional modification of the nucleotide sequence of an RNA molecule.
(B) The removal of introns and splicing of exons.
(C) The addition of a 5' cap and a 3' poly-A tail.
(D) The process of degrading old mRNA molecules.

205. The process of bacterial transformation involves:
(A) The transfer of genetic material through a bacteriophage.
(B) The transfer of genetic material through a cytoplasmic bridge.
(C) The uptake of naked DNA from the environment.
(D) The creation of a new species of bacteria.

206. Match List I (Mutation Type) with List II (Consequence) and select the correct answer using the options given below:
List I: (Mutation Type)
P. Silent Mutation
Q. Nonsense Mutation
R. Missense Mutation
S. Frameshift Mutation
List II: (Consequence)
1. Codon specifies a different amino acid
2. Codon specifies the same amino acid
3. Introduction of a premature stop codon
4. Reading frame is altered, leading to a

4. Superiority of a hybrid over its parents

(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

187. The "unit of replication" is also known as a replicon. In eukaryotes, chromosomes contain:
(A) Multiple replicons that activate sequentially during S phase.
(B) A single replicon, just like in bacteria.
(C) No specific replicons; replication starts randomly.
(D) Replicons that lack an origin of replication.

188. Given below are two statements:
Statement I: The process of conjugation requires direct contact between two bacterial cells.
Statement II: During conjugation, only the F plasmid is ever transferred.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

189. A frameshift mutation is caused by:
(A) A base substitution that changes an amino acid.
(B) An insertion or deletion of three nucleotides.
(C) An insertion or deletion of one or two nucleotides.
(D) A base substitution that creates a stop codon.

190. What is the role of euchromatin in gene regulation?
(A) It is a less condensed form of chromatin that is generally accessible to transcription machinery.
(B) It represents the permanently silenced parts of the genome.
(C) It is a highly condensed form of chromatin that is transcriptionally inactive.
(D) It is found only in prokaryotic cells.

191. Consider the following statements about gene silencing:
1. It can occur at the transcriptional level through DNA methylation.
2. It can occur at the post-transcriptional level through RNA interference.
3. It always involves the permanent deletion of a gene from the genome.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

192. In protein synthesis, the translocation step involves the movement of the peptidyl-tRNA from the:
(A) A site to the P site.
(B) P site to the A site.
(C) P site to the E site.
(D) E site to the A site.

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193. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Most eukaryotic genes are monocistronic.
Reason (R): A single eukaryotic mRNA molecule usually codes for only one polypeptide chain.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

194. The technique of in situ hybridization is used to determine the:
(A) Chromosomal location or tissue expression of a specific nucleic acid sequence.
(B) Sequence of a gene.
(C) 3D structure of a protein.
(D) Rate of DNA replication.

195. What is the genetic basis of heterosis, also known as hybrid vigour?
(A) Increased homozygosity which eliminates deleterious recessive alleles.
(B) Masking deleterious recessive alleles and/or overdominance at loci.
(C) The high rate of spontaneous mutation observed in hybrid organisms.

promote its translation.
(C) Act as a binding site for the ribosome.
(D) Mark the mRNA for degradation in the nucleus.

216. In the process of bacterial conjugation, what does an F+ cell possess that an F- cell lacks?
(A) A single chromosome.
(B) A rigid cell wall.
(C) An F (fertility) plasmid.
(D) Active ribosomes.

217. A significant role of euchromatin in the regulation of gene expression is that its:
(A) Loosely packed structure allows access for transcription factors and RNA polymerase.
(B) Tightly packed structure prevents gene expression.
(C) Presence on the Y chromosome determines male characteristics.
(D) Constant methylation state keeps genes permanently on.

218. A plant breeder crosses two different homozygous inbred lines. The resulting F1 generation is larger and more productive than either parent. This phenomenon is an example of:
(A) Heterosis (hybrid vigour)
(B) Inbreeding depression
(C) Aneuploidy
(D) Somatic mutation

219. Which of the following cellular processes is most directly affected by a mutation that inactivates the p53 tumor suppressor gene?
(A) Cell motility
(B) Glucose metabolism
(C) The cell cycle checkpoint in response to DNA damage.
(D) Protein secretion

220. The key difference between the lytic and lysogenic cycles of a bacteriophage is that:
(A) The lytic cycle involves DNA replication, while the lysogenic cycle does not.
(B) The lysogenic cycle involves integration of the phage genome into the host chromosome, while the lytic cycle leads to immediate host cell lysis.
(C) Only the lytic cycle can transfer genetic material between bacteria.
(D) The lytic cycle occurs in eukaryotes, while the lysogenic cycle occurs in prokaryotes.

221. Arrange the following components of the immune system in order of their typical response time to a new pathogen:
1. Adaptive immune response (T and B cells)
2. Physical barriers (skin)
3. Innate immune response (macrophages, neutrophils)
(A) 1, 2, 3
(B) 2, 3, 1
(C) 3, 2, 1
(D) 2, 1, 3

222. The wobble hypothesis explains how:
(A) A single tRNA can recognize multiple codons.
(B) The ribosome moves along the mRNA.
(C) DNA polymerase proofreads its work.
(D) The genetic code evolved.

223. What is the function of the enzyme DNA photolyase in DNA repair?
(A) It removes alkyl groups from guanine.
(B) It repairs pyrimidine dimers using energy from visible light.
(C) It excises a patch of damaged DNA.
(D) It corrects mismatches from replication errors.

224. Which of the following statements about transcription factors is correct?
(A) They are proteins that bind to specific DNA sequences to regulate transcription.
(B) They are enzymes that synthesize RNA.
(C) They are small RNA molecules that degrade mRNA.
(D) They are found only in prokaryotes.

225. What is the role of release factors in protein synthesis?
(A) To release the completed polypeptide chain from the tRNA in the P site.
(B) To release the ribosome from the endoplasmic reticulum.
(C) To release the mRNA from the ribosome.
(D) To release the transcription factors from the promoter.

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completely different downstream sequence
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-1, S-2

207. What is an oncogene?
(A) A gene that suppresses tumor growth.
(B) A mutated gene that contributes to the development of cancer.
(C) A gene involved in the normal regulation of the cell cycle.
(D) A gene that codes for an antibody.

208. Given below are two statements:
Statement I: The adaptive immune system is characterized by its ability to form memory cells.
Statement II: Upon a second encounter with the same pathogen, memory cells mount a faster and more potent immune response.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

209. The fidelity of DNA replication is extremely high due to:
(A) The high speed and processivity of the DNA polymerase enzyme complex.
(B) The presence of multiple origins of replication on each chromosome.
(C) Proofreading by DNA polymerase and post-replication mismatch repair.
(D) Simple A-T and G-C base pairing rules without any error correction.

210. What is the primary function of RNA polymerase II in eukaryotes?
(A) Transcribing genes that code for ribosomal RNAs.
(B) Transcribing genes that code for transfer RNAs.
(C) Transcribing genes that code for proteins (mRNAs) and some small RNAs.
(D) Replicating the DNA genome.

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211. Consider the following statements regarding the genetic code:
1. It is a triplet code where three nucleotides specify one amino acid.
2. It is degenerate, meaning some amino acids are coded by more than one codon.
3. It is overlapping, with each nucleotide being part of three separate codons.

Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

212. Which of the following is a post-translational modification involving the attachment of a lipid?
(A) Phosphorylation
(B) Glycosylation
(C) Prenylation
(D) Acetylation

213. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In eukaryotes, transcription occurs in the nucleus and translation occurs in the cytoplasm.
Reason (R): The nuclear membrane separates the two processes in space and time, allowing for extensive RNA processing before translation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

214. The evolution of multigene families is thought to occur primarily through which two processes?
(A) Gene loss and horizontal gene transfer.
(B) Gene duplication and subsequent divergence.
(C) Inversion and translocation.
(D) Point mutation and genetic drift.

215. The function of the poly-A tail on a eukaryotic mRNA is to:
(A) Signal for the start of translation.
(B) Increase the stability of the mRNA and

(B) An N-terminal presequence that forms an amphipathic helix.
(C) Co-translational import via the endoplasmic reticulum.
(D) A nuclear localization signal.

177. Which of the following is a mechanism of gene regulation unique to eukaryotes?
(A) Use of repressor proteins to block transcription.
(B) Regulation of gene expression through chromatin remodeling and histone modification.
(C) Regulation by attenuation.
(D) The use of operons to coordinate the expression of related genes.

178. A temperate bacteriophage is one that can:
(A) Choose between a lytic and a lysogenic life cycle.
(B) Only undergo the lytic cycle.
(C) Only infect eukaryotic cells.
(D) Replicate independently of a host cell.

179. In plant breeding, what is the primary goal of creating inbred lines?
(A) To maximize heterozygosity and hybrid vigour.
(B) To create plants that are resistant to all known pathogens.
(C) To produce genetically uniform, homozygous lines that can be used for creating predictable F1 hybrids.
(D) To introduce random mutations into the crop.

180. The p53 protein is often called the "guardian of the genome" because it can halt the cell cycle in response to:
(A) High levels of growth factors.
(B) DNA damage.
(C) The presence of nutrients.
(D) Successful completion of mitosis.

181. What is the function of the enzyme reverse transcriptase, which is central to the life cycle of retroviruses?
(A) It synthesizes DNA from a DNA template.
(B) It synthesizes DNA from an RNA template.
(C) It synthesizes RNA from a DNA template.
(D) It synthesizes protein from an RNA template.

182. A missense mutation refers to a change in the DNA sequence that:
(A) Results in the substitution of one amino acid for another in the protein.
(B) Leads to a premature stop codon.
(C) Does not change the amino acid sequence of the protein.
(D) Causes a shift in the reading frame.

183. Which of the following processes is NOT involved in the maturation of a eukaryotic mRNA transcript?
(A) 5' capping
(B) Splicing of introns
(C) Removal of exons
(D) Polyadenylation at the 3' end

184. The function of the enzyme aminoacyl-tRNA synthetase is to:
(A) Synthesize tRNA molecules.
(B) Attach the correct amino acid to its corresponding tRNA.
(C) Form peptide bonds during translation.
(D) Unwind the mRNA during translation.

185. The adaptive immune system exhibits "memory," which means that:
(A) It can remember and respond more effectively to a pathogen it has encountered before.
(B) It has a memory of all self-antigens from birth.
(C) It can transfer memory from one individual to another.
(D) All immune cells have a lifespan equal to that of the organism.

186. Match List I (Term) with List II (Definition) and select the correct answer using the options given below:
List I: (Term)
P. Oncogene
Q. Apoptosis
R. Heterosis
S. Transduction
List II: (Definition)
1. Programmed cell death
2. Transfer of DNA by a virus
3. A gene that has the potential to cause cancer

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226. Match List I (Process) with List II (Key Molecule/Structure) and select the correct answer using the options given below:
List I: (Process)
P. Transcription Initiation (Prokaryotic)
Q. Translation Initiation (Prokaryotic)
R. DNA Replication
S. RNA Splicing
List II: (Key Molecule/Structure)
1. Okazaki fragment
2. Spliceosome
3. Sigma factor
4. Shine-Dalgarno sequence
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

227. In eukaryotes, RNA polymerase I is primarily responsible for the synthesis of:
(A) Most ribosomal RNA (rRNA) precursors
(B) mRNA
(C) tRNA and 5S rRNA
(D) Small nuclear RNAs (snRNAs)

228. Given below are two statements:
Statement I: Post-translational modifications increase the functional diversity of the proteome.
Statement II: Phosphorylation, glycosylation, and ubiquitination are examples of post-translational modifications.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

229. The site of protein synthesis in a eukaryotic cell is the:
(A) Nucleus
(B) Mitochondrion
(C) Ribosome
(D) Golgi apparatus

230. A cell's decision to undergo apoptosis can be triggered by:
(A) An abundance of growth factors in the extracellular environment.
(B) The successful and error-free completion of the entire cell cycle.
(C) Internal signals like DNA damage or external death receptor ligands.
(D) A high concentration of intracellular ATP found within the cytosol.

231. Consider the following statements about DNA replication forks:
1. A single replication fork has both a leading strand and a lagging strand.
2. Synthesis on the leading strand is continuous, while on the lagging strand it is discontinuous.
3. Both newly synthesized strands are made in the 5' to 3' direction.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

232. Which of the following is an example of a structural motif found in DNA-binding proteins like transcription factors?
(A) Alpha-helix
(B) Beta-sheet
(C) Helix-turn-helix
(D) Random coil

233. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Alternative splicing allows a single gene to code for multiple protein isoforms.
Reason (R): By selectively including or excluding certain exons from the final mRNA, different protein products can be generated.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

234. The main difference between a tumor suppressor gene and a proto-oncogene is that:
(A) Tumor suppressor genes inhibit cell division, while proto-oncogenes promote it.
(B) Mutations in tumor suppressor genes are typically dominant, while mutations in

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explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

294. What is the role of ribosomes in protein synthesis?
(A) They are the machinery that reads the mRNA and synthesizes the polypeptide chain.
(B) They carry the genetic information from the nucleus.
(C) They attach the correct amino acids to the tRNAs.
(D) They provide the energy needed for peptide bond formation.

295. The phenomenon where the presence of a preferred carbon source (like glucose) prevents the expression of genes for metabolizing other carbon sources (like lactose) is called:
(A) Induction
(B) Repression
(C) Attenuation
(D) Catabolite repression

296. A key feature of the lagging strand during DNA replication is the synthesis of short DNA segments called:
(A) Promoters
(B) Okazaki fragments
(C) Replicons
(D) Telomeres

297. Post-translational modification by ubiquitination most commonly serves as a signal for:
(A) Protein activation.
(B) Targeting the protein for degradation by the proteasome.
(C) Targeting the protein to the cell membrane.
(D) Protein secretion.

298. In the genetic basis of cancer, oncogenes are like the 'accelerator' and tumor suppressor genes are like the 'brakes'. A cancerous state can arise from:
(A) A stuck accelerator and faulty brakes.
(B) A faulty accelerator and working brakes.
(C) A working accelerator and working brakes.
(D) A working accelerator and overly-sensitive brakes.

299. The structure of a tRNA molecule is often shown as a cloverleaf in two dimensions. Which part of this structure contains the anticodon?
(A) The anticodon loop
(B) The acceptor stem
(C) The D loop
(D) The TψC loop

300. Which component of the immune system is responsible for the rejection of a foreign tissue graft?
(A) The inflammatory response produced by the innate immune system cells.
(B) T-cells of the adaptive immune system recognizing foreign MHC molecules.
(C) Natural Killer (NK) cells acting alone to destroy non-self organisms.
(D) The proteins of the complement system acting in a cascade fashion.

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246. Match List I (Regulatory Protein/Sequence) with List II (Operon/System) and select the correct answer using the options given below:
List I: (Regulatory Protein/Sequence)
P. Lac Repressor
Q. Trp Repressor
R. CAP (Catabolite Activator Protein)
S. Attenuator sequence
List II: (Operon/System)
1. Lac operon (positive control)
2. Trp operon (fine-tuning)
3. Lac operon (negative control)
4. Trp operon (negative control)
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

247. The analysis of a Cot curve can reveal the proportion of highly repetitive, moderately repetitive, and unique sequences in a genome. Which component reassociates the fastest?
(A) Unique sequences
(B) Highly repetitive sequences
(C) Moderately repetitive sequences
(D) All components reassociate at the same rate.

248. Given below are two statements:
Statement I: The primary transcript (pre-mRNA) in eukaryotes is often much longer than the final mature mRNA.
Statement II: The difference in length is due to the removal of non-coding introns during the process of splicing.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

249. Which of the following is a function of the 5' cap on eukaryotic mRNA?
(A) It protects the mRNA from 5' exonuclease degradation and facilitates ribosome binding.
(B) It signals for termination of translation.
(C) It serves as the template for poly-A tail addition.
(D) It is involved in the splicing of the last intron.

250. The semi-conservative model of DNA replication means that after one round of replication:
(A) Each daughter DNA molecule consists of one parental and one new strand.
(B) One daughter DNA molecule is entirely new and one is entirely parental.
(C) Each daughter DNA molecule is a mosaic of parental and new segments.
(D) The parental DNA molecule remains intact while a new helix is formed.

251. Consider the following statements about the ribosome:
1. It is composed of rRNA and protein.
2. It has a large and a small subunit.
3. It is the site of protein synthesis.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

252. The regulation of initiation factors, for example by phosphorylation, is a mechanism to control gene expression at the:
(A) Transcriptional level
(B) Post-transcriptional level
(C) Translational level
(D) Post-translational level

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253. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Inbreeding often leads to a reduction in fitness known as inbreeding depression.
Reason (R): Inbreeding increases the frequency of heterozygotes in a population, which is disadvantageous.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

254. The process by which a bacteriophage integrates its genome into the host bacterium's chromosome is known as:
(A) Lysis
(B) Lysogeny
(C) Transfection
(D) Transformation

255. The role of B-cells in the adaptive immune system is to:
(A) Present antigens to cytotoxic T-cells.
(B) Phagocytose pathogens.
(C) Differentiate into plasma cells and produce antibodies.
(D) Regulate the immune response by secreting cytokines.

256. Which of the following best describes gene silencing?
(A) A process that results in the downregulation of gene expression, either at the transcriptional or post-transcriptional level.
(B) A process of increasing the expression of a particular gene.
(C) A mutation that introduces a stop codon.
(D) The process of gene duplication.

257. In the context of protein synthesis, what is the role of GTP?
(A) It is incorporated into the growing polypeptide chain.
(B) It provides the energy for amino acid activation.
(C) It provides energy for the binding of aminoacyl-tRNA and for the translocation of the ribosome.
(D) It provides the energy for peptide bond formation.

258. Which of the following proteins plays a central role in the execution phase of apoptosis by cleaving a wide range of cellular proteins?
(A) Bcl-2
(B) p53
(C) Caspase-3
(D) Ras

259. A restriction map of a plasmid is useful in recombinant DNA technology because it:
(A) Provides the full sequence of the plasmid.
(B) Shows the location of suitable sites for inserting a foreign DNA fragment.
(C) Indicates the plasmid's host range.
(D) Measures the rate at which the plasmid replicates.

260. The genetic code is "degenerate," meaning:
(A) It is not the same in all organisms.
(B) Multiple codons can code for the same amino acid.
(C) Each codon can code for multiple amino acids.
(D) The code is read in a non-overlapping manner.

261. What is the function of DNA helicase during DNA replication?
(A) It synthesizes new DNA strands.
(B) It unwinds the DNA double helix at the replication fork.
(C) It joins DNA fragments together.
(D) It relieves supercoiling ahead of the replication fork.

262. Which of the following is NOT a type of post-translational modification?
(A) Phosphorylation
(B) Glycosylation
(C) Polyadenylation
(D) Ubiquitination

263. A major difference between the innate and adaptive immune systems is that the adaptive immune system has:
(A) Phagocytic cells
(B) Physical barriers
(C) Specificity and memory
(D) A rapid, non-specific response

264. In prokaryotes, a group of genes that are transcribed together and controlled by a single promoter is called:
(A) An exon
(B) An intron
(C) An operon
(D) A replicon

265. What is the consequence of a nonsense mutation?
(A) A single amino acid is changed.
(B) The protein is truncated due to a premature stop codon.

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(C) The protein is unchanged.
(D) The reading frame is shifted.

266. Match List I (Item) with List II (Description) and select the correct answer using the options given below:
List I: (Item)
P. B-DNA
Q. Z-DNA
R. A-DNA
S. Okazaki Fragment
List II: (Description)
1. Short, wide, right-handed helix
2. Left-handed helix
3. Standard physiological form, right-handed helix
4. Discontinuous synthesis on lagging strand
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-4, Q-2, R-1, S-3

267. The process of RNA interference (RNAi) leads to gene silencing by:
(A) Causing the degradation of a specific target mRNA.
(B) Preventing the transcription of a specific gene.
(C) Methylating the promoter of a gene.
(D) Blocking the export of mRNA from the nucleus.

268. Given below are two statements:
Statement I: The C-value paradox highlights the fact that more complex organisms always have larger genomes.
Statement II: Genome size is a direct measure of the number of protein-coding genes.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

269. The enzyme that catalyzes the attachment of the correct amino acid to its tRNA molecule is:
(A) Peptidyl transferase
(B) Aminoacyl-tRNA synthetase
(C) RNA polymerase
(D) DNA ligase

270. Heterosis, or hybrid vigour, in plant breeding is exploited by:
(A) Continuously self-pollinating a single plant.
(B) Crossing two genetically diverse inbred parental lines to produce a superior F1 hybrid.
(C) Using mutagens to induce random genetic changes.
(D) Cloning plants vegetatively.

271. Consider the following statements regarding eukaryotic transcription:
1. It involves three different RNA polymerases.
2. It requires general transcription factors to initiate.
3. Transcription and translation are coupled and occur simultaneously.
Which of the statements given above is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

272. In recombinant DNA technology, what is the role of a vector?
(A) To carry a foreign piece of DNA into a host cell for replication.
(B) To cut the source DNA at specific sites.
(C) To provide the energy for ligation.
(D) To sequence the inserted DNA.

273. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): During DNA replication, one strand is synthesized continuously and the other discontinuously.
Reason (R): DNA polymerase can only synthesize DNA in the 5' to 3' direction, and the two template strands are antiparallel.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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9. (C) The tendency of hybrids to show qualities superior to those of both parents.
When two genetically distinct inbred lines are crossed, the resulting first-generation offspring often display enhanced phenotypic characteristics compared to either parental line. This increased vigour can manifest as greater size, improved yield, or better resistance to environmental stressors. This phenomenon is extensively utilized in agricultural breeding programs to maximize the productivity and uniformity of various food and commercial crops.

10. (A) Programmed cell death without inflammation
Systematic cellular suicide is a vital biological process that allows for the removal of damaged or unnecessary cells during development and homeostasis. Unlike accidental cell death, this highly regulated pathway involves characteristic morphological changes such as cell shrinkage and nuclear fragmentation. Because the cell contents are neatly packaged into membrane-bound bodies, there is no leakage that would trigger an inflammatory response.

11. (A) 1 and 2 only
Mature eukaryotic transcripts require several modifications to ensure stability and proper function. The five-prime end receives a modified guanine nucleotide, while the three-prime end is extended with multiple adenine residues. Splicing is also critical, but it specifically involves the excision of non-coding sequences known as introns and the subsequent ligation of the protein-coding regions referred to as exons.

12. (B) 3' to 5' exonuclease activity
During the synthesis of new genetic material, specialized enzymes possess an intrinsic ability to correct errors in base pairing immediately after they occur. If an incorrect nucleotide is incorporated at the growing end of the strand, the enzyme pauses and utilizes its specific degradative activity to remove the mismatched base. This mechanism significantly reduces the overall mutation rate during genome replication.

13. (A) Both A and R are true and R is the correct explanation of A.
The mapping of codons to amino acids exhibits a specific redundancy where most amino acids are associated with multiple nucleotide triplets. This characteristic is functionally significant because it provides a buffer against certain types of mutations, particularly those occurring at the third position of a codon. Consequently, the same polypeptide can be synthesized even if the underlying DNA sequence undergoes minor changes.

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14. (D) Proportion of repetitive and unique DNA sequences in a genome.
Reassociation kinetics involve denaturing double-stranded genetic material and then measuring the rate at which complementary strands pair back together. The complexity of the genome determines the shape of the resulting graph, as sequences that are present in many copies will encounter their matches much faster than unique sequences. This technique allows researchers to estimate the overall repetitiveness of different eukaryotic genomes.

15. (A) Loosely packed chromatin associated with active gene transcription.
Within the eukaryotic nucleus, genetic material exists in various states of compaction that directly influence its functional accessibility. The less condensed regions are typically rich in genes that are being actively expressed or are poised for expression. This open configuration allows transcription factors and the ribonucleic acid polymerase machinery to bind easily to the DNA templates, facilitating the synthesis of messenger RNA.

16. (B) TATA-binding protein (TBP)
Initiation of the transcription process in bacteria requires a core enzyme that associates with a specific protein factor to recognize promoter sequences. This factor is essential for guiding the machinery to the correct start site on the DNA template. In contrast, the protein that specifically recognizes the TATA box is a characteristic component of the transcription complex found in eukaryotic organisms.

17. (B) UAA
The termination of polypeptide chain synthesis is triggered when the translational machinery encounters specific nucleotide triplets in the messenger RNA. These sequences do not correspond to any aminoacyl-tRNA molecules. Instead, they are recognized by specialized

286. Match List I (Immune Cell) with List II (Key Feature) and select the correct answer using the options given below:
List I: (Immune Cell)
P. Macrophage
Q. B-Cell
R. Cytotoxic T-Cell
S. Helper T-Cell
List II: (Key Feature)
1. Differentiates into antibody-secreting plasma cell.
2. Kills virus-infected cells via recognition of MHC I.
3. Activates other immune cells; recognizes MHC II.
4. Phagocyte; acts as an antigen-presenting cell.
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

287. Which step is common to the repair of DNA damage via base excision repair and nucleotide excision repair?
(A) Removing the damaged base(s) and a segment of the DNA strand.
(B) Recognition of the damage by a DNA glycosylase.
(C) Use of light energy to reverse the damage.
(D) Correction of mismatched base pairs.

288. Given below are two statements:
Statement I: Polycistronic mRNA, which codes for multiple proteins, is common in prokaryotes.
Statement II: Monocistronic mRNA, which codes for a single protein, is the norm in eukaryotes.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

289. The role of the initiation factor IF3 in prokaryotic translation is to:
(A) Bind to the small ribosomal subunit and prevent its premature association with the large subunit.
(B) Bind to the A site to block incoming tRNAs.
(C) Bring the initiator tRNA to the ribosome.
(D) Provide GTP for translocation.

290. The activation of a proto-oncogene to an oncogene can occur through:
(A) Point mutation or gene amplification leading to increased activity.
(B) Complete deletion of the entire gene from the functional genome.
(C) Increased methylation of the promoter region of the given gene.
(D) Mutation that completely inactivates the resulting protein product.

291. Consider the following statements about heterosis:
1. It is the superiority of an F1 hybrid over its parents.
2. It is generally thought to be caused by the masking of deleterious recessive alleles.
3. Its effects are often diminished in the F2 and subsequent generations.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

292. The process of apoptosis is characterized by all of the following EXCEPT:
(A) Cell shrinkage and chromatin condensation.
(B) Formation of apoptotic bodies.
(C) Phagocytosis by neighboring cells without inflammation.
(D) Cell lysis and release of cellular contents causing inflammation.

293. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Transcription factors are crucial for regulating gene expression in eukaryotes.
Reason (R): They bind to specific DNA sequences and help recruit RNA polymerase to the promoter, thereby controlling the rate of transcription.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct

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proto-oncogenes are recessive.
(C) Proto-oncogenes are viral in origin, while tumor suppressor genes are cellular.
(D) Only proto-oncogenes are involved in cancer.

235. The transfer of genetic material from an Hfr bacterium to an F- bacterium via conjugation is characterized by:
(A) Transfer of a segment of the bacterial chromosome, with the recipient usually remaining F-.
(B) Rapid conversion of the F- cell to an F+ cell.
(C) Transfer of the entire bacterial chromosome.
(D) Transfer of genetic material via a bacteriophage.

236. The term "tRNA identity" refers to the specific features of a tRNA molecule that are recognized by:
(A) The corresponding mRNA codon.
(B) The ribosome during translocation.
(C) The correct aminoacyl-tRNA synthetase.
(D) The termination factor at a stop codon.

237. The 'C' in C-value stands for:
(A) Chromosome
(B) Content
(C) Complexity
(D) Cytosine

238. In the lac operon, the operator is a DNA sequence that:
(A) Codes for the lactose-metabolizing enzymes.
(B) Serves as the binding site for RNA polymerase.
(C) Serves as the binding site for the repressor protein.
(D) Codes for the repressor protein.

239. The technique of in situ hybridization would be most appropriate for answering which of the following questions?
(A) Determining cells in a developing embryo where a specific gene is expressed.
(B) Determining the complete DNA sequence of a specific functional eukaryotic gene.
(C) Determining the three-dimensional structure of a specific folded protein molecule.
(D) Determining the rate at which a specific protein is synthesized in the cytosol.

240. The cellular machinery that degrades proteins marked with ubiquitin is the:
(A) Ribosome
(B) Lysosome
(C) Peroxisome
(D) Proteasome

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241. Arrange the following steps of transcription by RNA polymerase in the correct order:
1. Elongation
2. Termination
3. Initiation
(A) 3, 1, 2
(B) 1, 3, 2
(C) 3, 2, 1
(D) 2, 3, 1

242. The Z-form of DNA is a:
(A) Left-handed double helix.
(B) Right-handed double helix.
(C) Triple helix.
(D) Single-stranded DNA molecule.

243. The process of adding a chain of adenine nucleotides to the 3' end of a eukaryotic mRNA is called:
(A) Polyadenylation
(B) Splicing
(C) Capping
(D) Editing

244. A key difference in the initiation of translation between prokaryotes and eukaryotes is:
(A) Eukaryotes use fMet-tRNA, while prokaryotes use Met-tRNA.
(B) Prokaryotic ribosomes bind to the Shine-Dalgarno sequence, while eukaryotic ribosomes typically scan from the 5' cap.
(C) Translation in prokaryotes occurs in the nucleus.
(D) Eukaryotic mRNA is polycistronic.

245. What is the function of helper T-cells in the adaptive immune response?
(A) To activate B-cells and cytotoxic T-cells.
(B) To directly kill infected cells.
(C) To produce antibodies.
(D) To engulf and digest pathogens.

ANSWERS

1. (B) The lack of correlation between genome size and biological complexity.
Genomic studies reveal that the total amount of DNA in a haploid genome does not necessarily reflect the physiological or morphological complexity of a particular organism. This observation highlights how large portions of eukaryotic genomes consist of non-coding sequences and repetitive elements, rather than just functional protein-coding genes that determine the biological complexity of the species.

2. (A) It predominates under conditions of high salt or dehydration.
Under normal physiological conditions, DNA typically exists in a right-handed double-helical configuration. However, when the environment undergoes dehydration or contains significantly high salt concentrations, the structure transitions into a different form. The standard right-handed form is most stable in aqueous, low-salt environments where the sugar-phosphate backbone remains fully hydrated and the nitrogenous bases are optimally stacked.

3. (C) DNA Polymerase III
In prokaryotic organisms, the primary enzyme responsible for the elongation of both the leading and lagging strands is a highly processive complex. It adds deoxyribonucleotides to the three-prime hydroxyl end of a growing primer or nascent strand. This specific enzyme complex ensures rapid and accurate genome duplication by working alongside other proteins at the replication fork during cell division.

4. (A) Both Statement I and Statement II are correct.
Regulation of gene expression involves specialized proteins that interact with regulatory DNA sequences. Some of these molecules facilitate the recruitment of the transcription machinery to the promoter, thereby increasing the rate of mRNA synthesis. Conversely, other proteins bind to specific inhibitory sites to obstruct the progress of polymerase, effectively reducing or preventing the transcription of targeted genes in the cell.

5. (C) Splicing
Modifications occurring after the translation process are essential for determining the final structure and function of a polypeptide. Common changes include the addition of phosphate groups, carbohydrate chains, or small tagging proteins like ubiquitin. However, the removal of introns and the joining of exons occur at the ribonucleic acid level within the nucleus before the mature messenger RNA is translated.

6. (A) P-2, Q-3, R-1, S-4
Different helical conformations exist based on environmental conditions and sequence motifs. A-form DNA appears during dehydration, whereas B-form is the standard biological structure. Z-form DNA is characterized by a left-handed helix with a zigzagging backbone, often found in alternating purine-pyrimidine sequences. Lastly, C-form DNA displays a specific number of base pairs per turn under certain low-humidity conditions in vitro.

7. (D) Transduction
Horizontal gene transfer in bacteria can occur through several distinct mechanisms. One specific process involves the accidental packaging of host chromosomal DNA into a viral capsid during the assembly of new bacteriophages. When these viral particles subsequently infect a different bacterial cell, they inject the previous host's genetic material, allowing for recombination and the acquisition of new genetic traits.

8. (A) Attaches the correct amino acid to its corresponding tRNA molecule.
Ensuring high fidelity during the translation of genetic information requires the precise coupling of specific amino acids to their matching adapter molecules. This two-step enzymatic reaction involves the activation of the amino acid with adenosine triphosphate followed by its transfer to the three-prime end of the tRNA. This process is catalyzed by enzymes that recognize specific structural identity elements.

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274. The "end-replication problem" in linear eukaryotic chromosomes is solved by the action of the enzyme:
(A) DNA ligase
(B) Telomerase
(C) Helicase
(D) DNA polymerase alpha

275. An operon is composed of which of the following elements?
(A) A promoter, an operator, and one or more structural genes.
(B) A single gene and its introns.
(C) A collection of unrelated genes on different chromosomes.
(D) A gene and its corresponding protein product.

276. In apoptosis, the "extrinsic pathway" is typically initiated by:
(A) Detection of extensive and irreparable DNA damage inside the cell.
(B) The release of cytochrome c from the mitochondria into the cytosol.
(C) A critical lack of essential growth factors for cellular survival.
(D) Binding of a death ligand to a death receptor on the cell surface.

277. The fidelity of translation is enhanced by a proofreading mechanism that is intrinsic to:
(A) The aminoacyl-tRNA synthetase
(B) The mRNA codon
(C) The ribosome
(D) The elongation factor Tu (EF-Tu)

278. Which of the following events happens during the processing of a primary RNA transcript in a eukaryote?
(A) Addition of a 5' cap
(B) Removal of exons
(C) Joining of introns
(D) Synthesis of a complementary DNA strand

279. The genetic exchange process in bacteria that involves a pilus and direct cell-to-cell contact is:
(A) Transformation
(B) Transduction
(C) Conjugation
(D) Transfection

280. A mutation in an oncogene that contributes to cancer is typically a:
(A) Gain-of-function mutation.
(B) Loss-of-function mutation.
(C) Silent mutation.
(D) Deletion of the entire gene.

281. The term 'replicon' refers to:
(A) A segment of DNA that codes for a repressor protein.
(B) A DNA or RNA molecule or a region of one that replicates as an autonomous unit.
(C) The protein complex that carries out DNA replication.
(D) The short RNA primer needed for DNA synthesis.

282. Which of the following is NOT a feature of B-DNA?
(A) It is a right-handed helix.
(B) It has about 10.5 base pairs per turn.
(C) The major groove is wide and the minor groove is narrow.
(D) The base pairs are tilted significantly from the helical axis.

283. The role of repressors in eukaryotic gene transcription is to:
(A) Bind to enhancers and increase transcription rate.
(B) Bind to silencers and decrease or prevent transcription.
(C) Act as a core component of the RNA polymerase.
(D) Splice introns out of the pre-mRNA.

284. Which type of RNA carries a specific amino acid to the site of protein synthesis?
(A) Transfer RNA (tRNA)
(B) Messenger RNA (mRNA)
(C) Ribosomal RNA (rRNA)
(D) Small nuclear RNA (snRNA)

285. In E. coli, which DNA polymerase is the main replicative enzyme responsible for synthesizing the leading and lagging strands?
(A) Polymerase I
(B) Polymerase II
(C) Polymerase III
(D) Polymerase IV

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protein release factors that catalyze the hydrolysis of the bond between the finished protein and the final tRNA molecule, releasing the completed chain into the cytoplasm.

18. (A) Localize specific DNA or RNA sequences within tissue sections.
Visualization of the spatial distribution of genetic material or gene transcripts is achieved using labeled probes that are complementary to the target sequences. This method is performed directly on preserved cells or thin layers of biological tissue. By observing where the probe binds, researchers can determine exactly which cells or cellular compartments contain the specific sequence of interest under different biological conditions.

19. (C) Has the potential to cause cancer when mutated or overexpressed.
Certain genes normally play essential roles in promoting cell growth and division. However, when these genes undergo specific alterations such as point mutations, chromosomal translocations, or amplification, they can become abnormally active. This permanent gain of function leads to uncontrolled cellular proliferation and the development of tumors, representing a critical step in the complex multi-step process of malignant transformation in tissues.

20. (D) It provides a rapid, non-specific response to pathogens.
The body possesses an immediate line of defense that acts against a wide variety of invading microorganisms without requiring prior exposure. This system utilizes physical barriers, chemical secretions, and specialized phagocytic cells to recognize conserved molecular patterns common to many pathogens. Although it lacks the specialized memory of other defense mechanisms, it is essential for controlling infections in their earliest stages.

21. (A) 1, 3, 2, 5, 4
Genome duplication begins with the recognition of the starting point by specific proteins, followed by the physical separation of the two strands to create a template. Short primers must be synthesized to provide the necessary hydroxyl groups for elongation. Finally, the main polymerizing enzyme builds the new strands, and any remaining breaks in the sugar-phosphate backbone are sealed together.

22. (B) Set of features in a tRNA molecule that are recognized by the correct aminoacyl-tRNA synthetase.
For translation to be accurate, each adapter molecule must be linked to its specific amino acid with high precision. This recognition is mediated by unique structural and chemical elements located within the acceptor stem, the anticodon loop, and other regions of the molecule. These specific identifiers ensure that the charging enzyme correctly distinguishes between many structurally similar molecules within the cell.

23. (D) Primase - Synthesizes DNA primers
During the process of genome duplication, specialized enzymes are required to initiate the synthesis of new strands because the main polymerizing enzymes cannot start from scratch. This particular enzyme creates short stretches of ribonucleotides rather than deoxyribonucleotides. These temporary sequences provide the free three-prime hydroxyl end that is necessary for the subsequent addition of DNA bases by the primary replication machinery.

24. (A) RNA interference (RNAi)
Cells can regulate gene expression by targeting specific messenger molecules for degradation or by blocking their translation into proteins. this process utilizes small double-stranded sequences that are processed into guide strands. These guides lead enzyme complexes to complementary targets, resulting in the precise downregulation of a particular gene. This mechanism is an important defense against viruses and a regulator of development.

25. (C) Conjugation requires direct cell-to-cell contact, while transformation involves uptake of free DNA.
Bacterial populations exchange genetic information through several distinct pathways. One method involves the physical connection between a donor and a recipient cell, often through a specialized appendage. Another method relies on the ability of certain cells to naturally absorb fragments of genetic material that have been released into the surrounding

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span the double membrane surrounding the genetic material. This ensures that only correctly processed and functional transcripts reach the cellular cytoplasm.

78. (A) They help assemble the 70S ribosome at the start codon of the mRNA.
Starting the translation process in bacteria requires the coordinated action of several protein factors. These factors ensure that the small ribosomal subunit correctly identifies the start signal and that the initiator tRNA is properly positioned. They also facilitate the subsequent binding of the large subunit, creating a functional complex that is ready to begin the synthesis of the new polypeptide chain.

79. (B) Masking deleterious recessive alleles with functional dominant ones.
One major theory explaining the increased vigour seen in hybrid offspring focuses on the interaction between different alleles at the same locus. Inbred parental lines often carry harmful recessive traits that are expressed due to homozygosity. When these lines are crossed, the offspring receive a functional dominant allele from one parent that compensates for the defective allele from the other, improving health.

80. (A) Lysozyme in tears and saliva
The innate immune system utilizes various strategies to prevent infection before pathogens can enter the body. In addition to physical structures, several biological fluids contain enzymes that can actively destroy the cell walls of certain bacteria. These chemical agents provide a continuous and non-specific defense at common entry points like the eyes and mouth, representing a vital component of first-line defenses.

81. (B) I-rRNA, II-mRNA, III-tRNA and 5S rRNA
Higher organisms possess multiple specialized enzymes for the synthesis of different types of ribonucleic acid. One enzyme is dedicated to producing the large ribosomal components within a specialized nuclear region. Another enzyme is responsible for transcribing the genes that code for proteins. A third enzyme handles the production of smaller molecules, including those that carry amino acids and the smallest ribosomal component.

82. (A) Shorter and wider with a tilted base pair orientation.
The physical structure of a double helix can vary significantly depending on its hydration level. Compared to the standard form, this alternative configuration is more compact and has a greater diameter. The nitrogenous bases are not perpendicular to the central axis but are instead tilted. This form is often observed in double-stranded ribonucleic acid and in DNA-RNA hybrid molecules during processes.

83. (B) Rho-independent termination involves the formation of a stable hairpin structure in the nascent RNA.
In bacteria, the completion of transcription can occur through a mechanism that does not require auxiliary protein factors. This process is driven by specific sequences at the end of the gene that cause the newly formed transcript to fold back on itself. This secondary structure, followed by a series of weak bonds, destabilizes the interaction between the transcript and the template, releasing the enzyme.

84. (B) A sequence of three nucleotides in mRNA.
The instructions for building a protein are encoded as a series of non-overlapping triplets within a messenger molecule. Each triplet corresponds to a specific amino acid or a signal to stop synthesis. During translation, these sequences are read by the ribosome, which matches them with complementary sequences on adapter molecules. This ensures that the correct sequence of blocks is assembled.

85. (C) Ras
Certain proteins within the cell act as molecular switches that transmit signals for growth and division. When the genes encoding these proteins undergo mutations that lock them in an active state, they continuously signal the cell to divide, regardless of external cues. This excessive signaling contributes to the formation and progression of tumors. This is a characteristic feature of many cancers.

86. (A) P-2, Q-1, R-2, S-2
The compartmentalization of cellular activities is a hallmark of complex organisms. The synthesis of genetic templates, the removal of non-coding sequences, and the duplication of the genome

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34. (A) Alters the nucleotide sequence of an RNA molecule after transcription.
In certain biological systems, the information encoded in a gene is not identical to the information finally translated into a protein. This discrepancy arises from processes that modify specific bases within the transcript after it has been synthesized. These changes, such as the conversion of one base to another, can create new start or stop signals and significantly alter protein function.

35. (C) A site (aminoacyl site)
During the elongation phase of protein synthesis, the translation machinery contains three distinct functional areas. The entry point is where the incoming molecule carrying the next amino acid in the sequence first interacts with the messenger template. Proper base pairing between the codon and anticodon at this location is essential for ensuring that the correct building block is added to the growing chain.

36. (D) Proteins are delivered to their correct destinations within or outside the cell.
After synthesis, polypeptides must be accurately directed to specific subcellular compartments or secreted into the extracellular environment to perform their functions. This biological process relies on specific signal sequences within the proteins that act as molecular addresses. Specialized transport systems recognize these signals and facilitate the movement of the proteins through membranes to their final functional locations within the organism.

37. (C) Site-specific recombination at att sites.
Certain viruses that infect bacteria can integrate their genetic material into the host genome through a highly precise mechanism. This process involves the interaction between specific attachment sequences present on both the viral and bacterial DNA. A specialized enzyme facilitates the breaking and joining of the DNA strands at these exact locations, allowing the virus to persist in a latent state.

38. (B) Crossing inbred lines to produce F1 hybrids with superior traits.
Agricultural improvement often involves the deliberate crossing of two genetically uniform but distinct parental stocks. The resulting first-generation plants typically exhibit a significant increase in productivity, uniformity, and resilience compared to their parents. This strategic use of genetic diversity allows breeders to combine desirable traits and overcome the negative effects of inbreeding, leading to superior crop performance in large-scale farming operations.

39. (D) Caspases
Programmed cell death is orchestrated by a specialized group of enzymes that act as molecular scissors to dismantle the cell from within. These enzymes are typically produced as inactive precursors that are activated in response to specific death signals. Once triggered, they cleave vital structural and functional proteins, leading to the orderly breakdown and packaging of the cell into small, membrane-bound bodies.

40. (A) It is characterized by specificity and memory.
The complex defense system found in higher vertebrates is defined by its ability to recognize and respond to unique molecular features of individual pathogens. Unlike more generalized responses, this system develops a long-lasting record of previous encounters, allowing for a much faster and more robust reaction if the same threat returns. This capability is the fundamental biological principle underlying the effectiveness of vaccines.

41. (C) Similar genes that arose by duplication of a single ancestral gene.
Eukaryotic genomes often contain groups of related sequences that share a high degree of structural and functional similarity. These clusters typically originate from an ancestral sequence that was copied during evolution. Over time, the individual members of the group may diverge slightly, allowing them to perform specialized roles or be expressed at different stages of development while maintaining a common origin.

42. (A) 4, 1, 2, 3
The transfer of genetic material between bacterial cells begins with initial physical interaction, followed by the establishment of a stable connection through a specialized structure. Once this bridge is formed, a single strand of the donor's plasmid is nicked and moved into the recipient. Finally, both cells synthesize the complementary

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processes newly synthesized transcripts. This complex is responsible for the precise excision of intervening sequences that do not code for proteins, ensuring that the final messenger molecule contains a continuous and accurate coding sequence.

61. (B) Restriction enzymes and DNA ligases
The ability to manipulate genetic material in the laboratory depends on two fundamental types of molecular tools. One type acts as precision scissors, cutting double-stranded molecules at specific nucleotide sequences. The second type acts as molecular glue, forming permanent bonds between different fragments. Together, these enzymes allow researchers to create hybrid molecules by inserting sequences from one source into another vector.

62. (A) 2, 4, 1, 3
The assembly of a polypeptide begins with the preparation of individual building blocks by linking them to their respective carrier molecules. Once the components are ready, the translation machinery assembles on the messenger template at the designated start site. The chain then grows through the sequential addition of amino acids until a termination signal is reached, triggering the release of the protein.

63. (B) Catabolite repression
Bacterial cells prioritize the use of energy-efficient carbon sources over others. When a preferred sugar is available, it triggers a regulatory mechanism that prevents the expression of genes required for metabolizing less efficient alternatives. This ensure that the cell does not waste resources synthesizing enzymes for a pathway it does not currently need. This phenomenon is a classic example of metabolic efficiency.

64. (D) Statement I is incorrect but Statement II is correct.
The mechanisms ensuring the accuracy of genetic processes differ significantly in their biological impact. Errors during the duplication of the genome are permanent and are passed on to daughter cells, potentially leading to inherited disorders. In contrast, mistakes made during the synthesis of transcripts are only temporary, as the faulty molecules are soon degraded and replaced by new, correctly synthesized versions.

65. (B) A permanent alteration in the DNA sequence of a gene.
Genetic variation can arise from a lasting change in the arrangement or composition of nucleotides within a specific region of the genome. These alterations can involve the substitution of a single base, the insertion of new material, or the deletion of existing segments. Once established, these changes are copied during replication and can lead to variations in the resulting protein products.

66. (A) Determining the chromosomal location of a specific gene.
Physical mapping of genetic traits is essential for modern crop improvement. By using labeled probes that bind to complementary sequences on intact chromosomes, researchers can visually pinpoint exactly where a specific sequence is located. This information is invaluable for identifying the arrangement of genes, understanding the structure of the genome, and facilitating the selection of desirable traits through molecular breeding techniques.

67. (C) Recognizes the promoter to help RNA polymerase bind the start site.
In bacteria, the synthesis of ribonucleic acid requires a protein factor that provides the necessary specificity for starting the process at the right location. This factor associates with the core enzyme to identify and bind to conserved sequences upstream of the coding region. Once the transcription bubble has formed and synthesis has successfully initiated, the factor is typically released from the complex.

68. (A) P-3, Q-4, R-1, S-2
Various tools and concepts are used to characterize genomes. One paradox describes the lack of relationship between genome size and organismal complexity. Kinetic graphs reveal the distribution of repetitive and unique sequences. Physical diagrams show the sites where specific enzymes cleave the DNA. Finally, clusters of related genes demonstrate how duplication and divergence drive the evolution of specialized functions in organisms.

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that the genetic information is efficiently and accurately converted into functional proteins.

52. (B) Phagocytosis
The innate immune system employs specialized cells capable of identifying and internalizing foreign particles or invading microorganisms. This process involves the extension of the cell membrane to surround the target, eventually bringing it into the cell within a membrane-bound vesicle. Once inside, the vesicle fuses with digestive enzymes to neutralize and break down the threat, serving as a primary defense mechanism.

53. (A) Both A and R are true and R is the correct explanation of A.
Eukaryotic organisms can generate a diverse range of proteins from a relatively limited number of genes. This is achieved by varying the selection of coding sequences included in the final mature transcript. By joining different combinations of segments, a single gene can produce multiple protein variants with distinct functions or properties, significantly expanding the overall complexity and versatility of the proteome.

54. (C) Where the DNA double helix is unwound to create two single-stranded templates.
During the process of genome duplication, a specific Y-shaped structure forms as the two strands of the parent molecule are pulled apart. This separation is necessary because the polymerizing enzymes require access to single-stranded templates to build new complementary strands. The movement of this structure along the DNA allows for the continuous and discontinuous synthesis of the new genetic material.

55. (C) Have the F factor integrated into their chromosome.
In bacterial populations, certain cells exhibit a high capacity for transferring chromosomal genes to other individuals. This occurs when a fertility plasmid becomes physically incorporated into the main circular DNA molecule of the bacterium. During conjugation, the cell attempts to transfer its entire chromosome starting from the integrated plasmid site, although the process is often interrupted before the full sequence is moved.

56. (C) Small nuclear RNA (snRNA)
The removal of non-coding regions from eukaryotic transcripts is mediated by a complex of proteins and specialized ribonucleic acid molecules. These small RNAs are essential for recognizing the specific boundary sequences at the ends of the non-coding segments. They facilitate the precise cutting and rejoining of the coding regions, ensuring that the resulting messenger molecule can be correctly translated into a protein.

57. (B) Poly(A) Polymerase
After the synthesis of a eukaryotic transcript, the three-prime end undergoes a specific maturation step. An enzyme adds a long sequence of adenine nucleotides without following a DNA template. This modification is crucial for the stability of the messenger molecule, its export from the nucleus, and its efficient translation by the ribosomal machinery in the cytoplasm of the eukaryotic cell.

58. (D) Polyubiquitination
Cells maintain protein quality control by marking damaged or unnecessary molecules for destruction. This involves the covalent attachment of multiple copies of a small regulatory protein. Once a chain of these tags is formed, it is recognized by a large proteolytic complex that unfolds the protein and breaks it down into small peptides. This selective degradation is essential for regulating various cellular processes.

59. (B) Normal cellular genes that regulate cell growth and division.
Within a healthy cell, certain genes are responsible for producing proteins that drive the cell cycle and promote proliferation. These genes are essential for normal development and tissue repair. However, if they acquire mutations that make them hyperactive, they can contribute to the development of cancer. In their normal, non-mutated state, these genes are critical components of the cellular growth machinery.

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60. (B) snRNA - Component of the spliceosome for intron removal.
Different varieties of ribonucleic acid perform specialized tasks within the cell. One particular type is found within the nucleus and works alongside proteins to form the machinery that

a heterozygous state. As these detrimental alleles become more frequent in a homozygous form, the overall health and productivity decline.

96. (A) It binds to a silencer or operator sequence to block or reduce transcription.
Gene expression can be actively inhibited by specialized proteins that interact with specific control regions in the DNA. These molecules can work by physically obstructing the attachment of the transcription machinery or by recruiting other factors that compact the local structure of the genetic material. By preventing the synthesis of messenger RNA, these proteins play a crucial role in precise regulation.

97. (C) To remove introns and join exons.
In eukaryotic cells, the initial transcript contains both coding and non-coding sequences. To produce a functional messenger molecule, a large complex made of ribonucleic acids and proteins must accurately identify and remove the non-coding regions. Once these segments are excised, the remaining coding sequences are precisely linked together. This processing is essential for the subsequent synthesis of a correct protein product.

98. (A) A specific amino acid to its 3' end by an aminoacyl-tRNA synthetase.
The preparation of adapter molecules for protein synthesis involves the energy-dependent attachment of an amino acid to a specific ribonucleic acid molecule. This reaction is catalyzed by a highly selective enzyme that recognizes both the correct amino acid and its corresponding carrier. This link ensures that the translation machinery can accurately incorporate each building block into the growing chain according to instructions.

99. (B) The aminoacyl-tRNA synthetase, which has an editing site.
Maintaining the accuracy of protein synthesis depends on the correct pairing of amino acids with their adapter molecules. To achieve this, certain enzymes possess a secondary functional region that can detect and remove incorrectly attached building blocks. If an amino acid with a similar structure is accidentally joined, the enzyme hydrolyzes the bond before the molecule can participate in translation, ensuring fidelity.

100. (D) F1 generation resulting from a cross between two diverse parents.
The maximum increase in productivity and vigour is typically observed in the first generation of offspring produced from the mating of two genetically distinct and uniform parental stocks. These hybrids benefit from a unique combination of alleles that masks harmful traits and provides superior performance. However, this advantage is often reduced in subsequent generations as the genetic combinations begin to segregate.

101. (A) 1, 2, 4, 3
The assembly of the eukaryotic transcription machinery follows a precise hierarchical sequence. It begins with the recognition of a specific promoter element by a key protein complex. This initial binding event recruits additional factors and the primary enzyme to the start site. Once the DNA is unwound to form a bubble, the enzyme's tail is modified, allowing it to begin synthesis.

102. (B) The genome has a high proportion of unique, non-repetitive DNA sequences.
Reassociation kinetics reveal the underlying organization and complexity of a particular genome. A higher value on the resulting curve indicates that the genetic material requires more time to find complementary partners, which is characteristic of sequences present in only a single copy. In contrast, smaller values suggest a high degree of repetitiveness, where matching strands encounter each other quite rapidly.

103. (C) Gene duplication followed by divergence in sequence and function.
The presence of multiple related sequences in a genome is often the result of an evolutionary process where an ancestral sequence is copied. Over many generations, the different copies accumulate mutations independently, allowing them to acquire new specialized roles or be expressed under different conditions. This mechanism is a primary driver of biological innovation and the expansion of functional diversity.

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69. (B) Flexible pairing between the third base of a codon and the first base of its anticodon.
The rules governing base pairing are not identical at every position during the translation of the genetic code. While the first two positions require strict adherence to standard rules, the interaction at the third position of the triplet is more permissive. This flexibility allows a single adapter molecule to recognize several different codons that represent the same amino acid, increasing efficiency.

70. (B) Bind to enhancer sequences and facilitate the assembly of the transcription machinery.
Gene expression is often upregulated by proteins that interact with regulatory sequences located at various distances from the start site. These molecules typically help to stabilize the binding of the general transcription apparatus or recruit enzymes that modify the local structure of the genetic material. By making the promoter more accessible, these proteins significantly increase the overall rate of mRNA synthesis.

71. (B) 1 and 2 only
Polypeptides must be correctly routed to their intended cellular destinations to function properly. This process relies on specific amino acid motifs that act as navigational signals. Some signals direct the synthesis machinery to the membrane of a specific organelle, while others allow fully folded proteins to enter the nucleus through specialized pores. Not all proteins are synthesized in the same location.

72. (C) A single type of RNA Polymerase
Bacterial organisms simplify the process of gene expression by utilizing one primary enzyme complex to synthesize all classes of ribonucleic acid. This versatile machinery is capable of producing the molecules that carry genetic information, the structural components of the translation apparatus, and the adapter molecules that deliver amino acids. Diversity in gene expression is achieved through various regulatory factors.

73. (A) Both A and R are true and R is the correct explanation of A.
Horizontal gene transfer in bacteria is facilitated by a mechanism that involves the direct movement of DNA between two adjacent cells. This process is dependent on the formation of a temporary bridge that physically links the donor to the recipient. The genetic information is then unidirectionally moved through this connection, allowing the recipient to acquire new traits such as antibiotic resistance.

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74. (A) A purine with another purine, or a pyrimidine with another pyrimidine.
Point mutations can be classified based on the chemical nature of the substituted bases. One specific type involves the replacement of a single-ringed nitrogenous base with another single-ringed base, or a double-ringed base with another double-ringed base. These changes preserve the general chemical structure of the genetic sequence and occur more frequently in nature than substitutions that cross between these two categories.

75. (C) Uniformity and increased yield compared to parental lines.
Modern agriculture relies heavily on the production of first-generation crosses between distinct parental lines. These offspring are highly valued because they combine the best traits from both parents while exhibiting a high degree of phenotypic consistency. This makes large-scale harvesting and management more efficient while significantly boosting the overall productivity and resilience of the crop compared to traditional open-pollinated varieties.

76. (A) Inhibit cell cycle progression or induce apoptosis in response to DNA damage.
Certain proteins act as critical checkpoints to maintain the integrity of the genome. When a cell sustains damage or undergoes abnormal stress, these proteins can temporarily halt the division process to allow for repairs. If the damage is too severe, they trigger a pathway that leads to the safe elimination of the cell, thereby preventing the transmission of mutations and cancer.

77. (D) Selective export via nuclear pores using specific signal receptors.
The movement of mature transcripts from their site of synthesis to the translation machinery is a highly controlled process. It requires the interaction between the RNA-protein complex and specialized transport factors. These factors guide the molecules through large channels that

strand to restore the double-stranded circular DNA molecule in both.

43. (D) It is overlapping.
The system used by cells to translate nucleotide sequences into proteins has several defining properties. It uses sets of three bases, and most amino acids are represented by more than one combination. Importantly, once translation begins at a specific start site, each base is read as part of only one triplet, ensuring a linear and predictable sequence of amino acids is produced.

44. (A) Both Statement I and Statement II are correct.
Starting protein synthesis in complex cells is a highly regulated multi-step process. It requires the coordinated action of numerous protein factors that help the small ribosomal subunit associate with the messenger ribonucleic acid. This complex then moves along the transcript from the modified start end, searching for the specific triplet sequence that signals the beginning of the polypeptide chain to be synthesized.

45. (C) An origin of replication and may have a terminus.
A functional unit of genetic material that undergoes duplication as a single entity contains the specific sequences necessary to control the process. This includes a starting point where the replication machinery first assembles and initiates the unwinding of the double helix. Depending on the organism, it may also contain specific sequences that signal the end of the duplication process for that unit.

46. (D) Direct repair by DNA photolyase
Exposure to ultraviolet light can cause adjacent bases in a genetic sequence to bond abnormally, creating structural distortions. Some organisms possess a specialized enzyme that can directly reverse this damage without removing any nucleotides. This enzyme captures the energy from visible light to break the improper bonds, effectively restoring the original structure of the DNA molecule in a single enzymatic step.

47. (C) P-3, Q-2, R-1, S-4
Many antibiotics function by disrupting various stages of protein synthesis in bacteria. Some prevent the entry of new building blocks into the ribosome, while others block the formation of the bonds between amino acids. Some molecules mimic the structure of a carrier molecule, causing the chain to stop prematurely, while others interfere with the accuracy of reading the genetic template itself.

48. (B) Modification of histone proteins, such as acetylation and methylation.
The accessibility of genes for transcription is often determined by the chemical state of the proteins around which the DNA is wrapped. By adding or removing specific chemical groups to these proteins, the cell can switch between a tightly packed, inactive state and a more relaxed, active state. This epigenetic mechanism is central to the long-term regulation of eukaryotic gene expression.

49. (C) Transfer RNA (tRNA)
Protein synthesis requires a bridge between the nucleotide sequence of a messenger molecule and the amino acid sequence of a polypeptide. This role is filled by specialized ribonucleic acid molecules that carry a specific amino acid at one end and possess a complementary three-base sequence at the other. This dual functionality allows them to accurately position each building block during translation.

50. (B) Crossing the inbred line with a genetically different line (outcrossing).
A decline in fitness and productivity often occurs in plants when they are self-pollinated over several generations due to the accumulation of homozygous recessive alleles. To restore vigour, breeders introduce genetic diversity by mating the affected plants with individuals from an unrelated population. This process restores the heterozygous state and masks harmful recessive traits, leading to improved health and growth performance.

51. (D) 1, 2 and 3
The protein-synthesizing machinery in complex cells is a large ribonucleoprotein complex composed of two distinct parts. One part is responsible for accurately decoding the messenger transcript by facilitating codon-anticodon interactions. The other part contains the catalytic site necessary for linking amino acids together into a chain. Together, these subunits ensure

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all occur within the membrane-bound organelle that houses the chromosomes. In contrast, the actual assembly of polypeptide chains typically takes place in the surrounding fluid environment of the cell where ribosomes are located.

87. (D) Accurate proofreading by DNA polymerase
Genetic material is constantly subject to various chemical and physical stresses that can alter its sequence. Bases may be lost or modified through spontaneous chemical reactions, and environmental factors like radiation can create improper bonds between adjacent bases. While these processes lead to damage, the cell possesses high-fidelity duplication systems that actively detect and correct errors as they occur.

88. (C) Statement I is correct but Statement II is incorrect.
Bacteria can acquire new genetic traits by directly absorbing fragments of DNA from their surroundings. This is a natural process that increases genetic diversity. However, the movement of genetic material mediated by a viral vector is a different mechanism. The direct transfer of genetic information through a physical connection between two bacterial cells represents yet another distinct pathway for gene exchange.

89. (A) Normal development and tissue homeostasis.
The orderly removal of cells is essential for shaping tissues and organs during the growth of an organism. For example, it is responsible for the elimination of tissue between developing digits. Furthermore, this process helps maintain a stable cell population in adult tissues by balancing the continuous production of new cells, thereby preventing the accumulation of damaged or potentially harmful cells.

90. (B) Alternative splicing
The traditional view of one gene leading to a single product has been expanded by the discovery of complex processing mechanisms. By selectively including or excluding different coding segments from the initial transcript, a cell can produce a variety of distinct messenger molecules. This allows for the synthesis of multiple protein isoforms with different functions from a single genomic sequence, greatly increasing diversity.

91. (D) 1, 2 and 3
During the cyclic process of adding building blocks to a growing polypeptide, several steps must occur in precise order. First, a new carrier molecule enters the ribosome. Next, a bond is formed between the existing chain and the new amino acid. Finally, the entire complex shifts along the template to the next position, a move driven by energy-rich molecules and factors.

92. (B) Present processed antigens to T cells.
Specialized surface proteins play a vital role in allowing the immune system to monitor the internal state of cells. These proteins bind to small fragments of peptides derived from pathogens and display them on the cell exterior. This presentation is essential for the activation of lymphocytes, which can then recognize and eliminate infected cells, providing a targeted and effective defense against diseases.

93. (A) Both A and R are true and R is the correct explanation of A.
While most DNA adopts a right-handed helical form, certain nucleotide arrangements can shift into an alternative, left-handed configuration. This structural change is often triggered by the presence of alternating purine and pyrimidine bases. High salt concentrations or specific chemical modifications can stabilize this zigzagging backbone. This conformation is biologically relevant and may play a role in regulating the expression of genes.

94. (B) A single damaged or incorrect base, such as one that has been deaminated or oxidized.
Cells possess a specialized pathway to fix minor lesions that do not significantly distort the double helix. This process begins with the identification and removal of a single modified or misplaced nitrogenous base by a specific enzyme. The resulting gap in the strand is then filled with the correct nucleotide by a polymerase and the backbone is sealed, restoring the genetic integrity.

95. (B) Expression of deleterious recessive alleles in homozygotes.
Repeated mating between close relatives results in a significant increase in the proportion of gene pairs that are identical. This shift in the genetic makeup of a population can lead to the emergence of harmful traits that were previously hidden in

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environment from lysed cells, incorporating this information into their own genomes.

26. (A) Natural Killer (NK) cells
The immune system is divided into two major branches, one of which provides highly specific, long-term protection through memory. This branch utilizes specialized lymphocytes and secreted proteins that target specific antigens. While many cells participate in the overall response, some large granular lymphocytes act as part of the immediate, non-specific defense by destroying infected or cancerous cells without prior sensitization.

27. (B) P-3, Q-1, R-2, S-4
Fundamental biological processes are driven by specialized enzymatic complexes. Genome duplication requires a primary polymerase for elongation. Transcription is mediated by an enzyme that synthesizes ribonucleic acids from a DNA template. Protein synthesis relies on the accurate charging of tRNAs by specific synthetases. Furthermore, various damage reversal mechanisms, such as those triggered by light, utilize specific enzymes like photolyase to maintain genomic integrity.

28. (B) Bind and deliver the aminoacyl-tRNA to the A-site of the ribosome.
During the elongation phase of protein synthesis in bacteria, a specialized protein factor forms a complex with an energized aminoacyl-tRNA and a molecule of guanosine triphosphate. This complex ensures that the correct amino acid-carrying molecule is positioned properly within the entry site of the translation machinery. This step is crucial for maintaining the speed and accuracy of the polypeptide assembly process.

29. (C) The insertion or deletion of nucleotides in a number not divisible by three.
Genetic information is read in sets of three bases, meaning any addition or removal of nucleotides that is not a multiple of three will disrupt the entire downstream reading pattern. This type of mutation typically results in a completely different sequence of amino acids and often introduces a premature termination signal, leading to the production of a non-functional or truncated protein.

30. (D) Increased homozygosity exposing deleterious recessive alleles.
Mating between closely related individuals leads to a significant reduction in genetic variation within the offspring. This process increases the likelihood that rare, harmful alleles normally masked in a heterozygous state will pair up. When these alleles become homozygous, they manifest as reduced fitness, decreased fertility, and poor overall health, a biological phenomenon that is common in many plant and animal populations.

31. (C) 2 and 3 only
Certain DNA sequences can adopt an unconventional double-helical structure characterized by a left-handed orientation. In this form, the sugar-phosphate backbone follows a non-linear, zigzag path instead of the smooth curve seen in standard forms. This conformation is typically favored by sequences that contain alternating purine and pyrimidine bases and can be stabilized by specific modifications or environmental conditions like high salinity.

32. (B) To cut DNA at specific recognition sites, creating fragments of different sizes.
Specialized bacterial enzymes are used to recognize and cleave specific palindromic nucleotide sequences within a DNA molecule. By applying different enzymes and measuring the resulting fragment lengths through electrophoresis, researchers can determine the relative positions of these recognition sites. This information allows for the construction of a physical diagram that serves as a useful tool for characterizing and manipulating genetic material.

33. (A) Both A and R are true and R is the correct explanation of A.
Eukaryotic transcripts undergo significant modifications before they are exported to the cytoplasm. One essential change involves the addition of a modified nucleotide to the start of the molecule during early synthesis. This modification serves multiple purposes, including shielding the transcript from enzymatic degradation and acting as a critical recognition signal for the ribosome to begin the translation of the genetic code.

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104. (B) Eukaryotes have multiple specialized RNA polymerases, while prokaryotes have one main type.
Complex organisms have evolved specialized molecular machineries to handle the transcription of different categories of genes. While simpler cells rely on a single primary enzyme complex for all synthesis tasks, higher organisms utilize distinct enzymes for producing ribosomal components, protein-coding transcripts, and small functional molecules. This specialization allows for more sophisticated and nuanced levels of regulation within the larger eukaryotic cell.

105. (A) Resembles an aminoacyl-tRNA and causes premature chain termination.
Certain chemical compounds can disrupt protein synthesis by mimicking the structure of the molecules that carry amino acids. During the elongation phase of translation, such a compound can enter the ribosome and be linked to the growing polypeptide chain. Because the molecule lacks the necessary structure for further additions, the chain is released prematurely, resulting in the production of non-functional fragments.

106. (B) P-2, Q-3, R-4, S-1
The body's defense mechanism utilizes various specialized cells to maintain health and eliminate pathogens. Some cells are responsible for producing soluble proteins that target invaders, while others directly destroy host cells that have been compromised by viruses. Regulatory cells coordinate these activities by releasing signals, and scavenger cells identify, ingest, and present foreign markers to activate other parts of the system.

107. (B) The availability of charged tryptophan tRNA.
Gene expression in certain bacterial pathways is controlled by a mechanism that links transcription directly to the translation of a short leader sequence. If the cell has an abundance of a specific amino acid, the translation of this sequence proceeds rapidly, causing the transcript to fold in a way that terminates synthesis early. This ensures that the cell avoids wasting energy.

108. (A) Both Statement I and Statement II are correct.
Ensuring that polypeptides are delivered to their correct functional locations is essential for cellular organization. This process depends on specific amino acid sequences that act as molecular tags, guiding the proteins through various transport pathways. These signals are recognized by specialized machinery that facilitates the translocation of the proteins across membranes to their final destinations, whether inside organelles or outside the cell.

109. (B) It is a left-handed helix with a zigzagging sugar-phosphate backbone.
While most genetic material exists in a smooth, right-handed double helix, certain sequences can adopt a more angular and opposite-oriented structure. This form is characterized by a specific arrangement where the backbone appears to zigzag rather than curve gradually. This conformation is typically found in regions with high concentrations of alternating purine and pyrimidine bases and is influenced by environmental conditions.

110. (A) A codon that specifies an amino acid being changed to a stop codon.
A point mutation that results in the creation of a termination signal where a coding triplet should be can have drastic effects on the resulting protein. When the translational machinery reaches this signal, it stops synthesis prematurely. This typically leads to the production of a truncated polypeptide that lacks its functional domains and is often quickly degraded by the cell's quality control systems.

111. (D) 1, 2 and 3
Maintaining the continuity of the genetic material requires an enzyme capable of repairing breaks in the sugar-phosphate backbone. This enzyme facilitates the formation of a permanent bond between adjacent nucleotides, a step that is essential for connecting short segments on the discontinuous strand during replication. It is also a vital tool in laboratory techniques used to join different fragments of DNA.

112. (A) An initiator caspase, activated by the apoptosome.
The internal pathway for programmed cell death involves the formation of a large protein complex in response to cellular stress. This complex serves as a platform to recruit and activate a specific protease, which then triggers a cascade of further

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specific sequence element by a large complex that contains a protein specialized for binding the TATA box. This initial binding event serves as a foundation for the subsequent recruitment of the entire machinery.

130. (C) Anticodon loop
The adapter molecule responsible for bringing building blocks to the ribosome contains a specific three-nucleotide sequence that is essential for decoding. This sequence interacts directly with the complementary triplets on the messenger template through base pairing. This precise interaction ensures that each amino acid is incorporated into the growing polypeptide chain at the correct position according to the genetic instructions.

131. (D) 1, 2 and 3
After a polypeptide chain has been synthesized, it can undergo various chemical changes that alter its function, stability, or location. These modifications include the addition of phosphate or sugar groups, as well as alterations to the proteins that package the genetic material. Such changes are essential for regulating enzyme activity, signaling pathways, and the overall organization of the eukaryotic cell.

132. (B) Containing both pro-apoptotic and anti-apoptotic members that control mitochondrial outer membrane permeabilization.
A specific family of proteins acts as a critical regulator of the decision to undergo programmed cell death. This group includes both molecules that promote the release of death signals from mitochondria and molecules that inhibit this process. The balance between these opposing factors determines whether the cell survives or triggers the cascade of events that leads to its systematic disassembly.

133. (A) Both A and R are true and R is the correct explanation of A.
The accessibility of genes for transcription is directly related to the physical state of the genetic material within the nucleus. Regions that are loosely organized and less condensed are more easily reached by the enzymes and factors required to initiate synthesis. Consequently, genes located in these areas are more frequently expressed than those found in tightly packed, condensed regions of the genome.

134. (B) DNA Polymerase I (in prokaryotes)
During the duplication of the genome, temporary ribonucleotide sequences used to initiate synthesis must be removed and replaced with deoxyribonucleotides. In bacterial cells, a specialized enzyme performs this dual role, utilizing its degradative activity to excise the primers and its synthesis activity to fill the resulting gaps. This ensures that the final new strand consists entirely of permanent DNA bases.

135. (A) Aminoacyl-tRNA synthetase
Accurate translation depends on the precise recognition of carrier molecules by the enzymes that charge them with amino acids. This recognition is mediated by specific structural and chemical features of the carrier, which differentiate it from all others. These identity elements are essential for maintaining the fidelity of the genetic code, ensuring that each adapter is linked to its correct building block.

136. (B) Regulation of translation initiation by phosphorylation of initiation factors (e.g., eIF2).
Cells can control the rate of protein synthesis by modifying the activity of the factors involved in starting the translation process. For example, adding a phosphate group to a key factor can inhibit its ability to facilitate the assembly of the ribosome on the messenger template. This mechanism allows the cell to rapidly respond to stress or changes in the environment.

137. (B) Transfer of a portion of the Hfr cell's chromosome, but the recipient usually remains F-.
When a bacterium with an integrated fertility factor mates with another cell, it attempts to transfer its entire chromosome. However, the process is usually interrupted before completion because of the large size of the chromosome and the fragility of the connection. As a result, only a segment of the genetic material is moved, and the recipient rarely receives the full plasmid sequence.

138. (B) The speed and specificity of the response.
The body's defense system features two complementary branches. One provides an

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121. (B) Transformation is the uptake of naked DNA, while transduction involves a bacteriophage vector.
Bacteria can acquire new genetic information through different horizontal pathways. One involves the absorption of free DNA fragments from the environment, while another requires a viral intermediary that carries genetic material from one host to another. These mechanisms allow for the spread of beneficial traits like antibiotic resistance through a population without the need for direct cell-to-cell contact between individuals.

122. (A) 1, 2, 3, 4
Repairing minor damage to individual bases follows a specific enzymatic pathway. It begins with the precise removal of the damaged base, followed by a cut in the sugar-phosphate backbone to allow for further processing. A polymerase then adds the correct nucleotide using the opposite strand as a template. Finally, an enzyme seals the remaining break, restoring the integrity of the sequence.

123. (A) Superior fitness of the heterozygote over both homozygous genotypes.
One explanation for the enhanced vigour seen in hybrid offspring suggests that individuals carrying two different versions of a gene may have a biological advantage over those carrying two identical versions. This superiority can result from various factors, such as increased metabolic flexibility or a broader range of functional proteins. This advantage contributes to the overall improved health and productivity of hybrids.

124. (B) Immediate response upon first exposure
The complex defense system that provides specific and long-lasting protection requires a period of activation when it first encounters a new threat. This delay occurs because the system must identify the antigen and allow for the proliferation of the specific cells needed for a robust response. While slower initially, it creates a memory that ensures a rapid reaction to subsequent exposures.

125. (C) A frameshift mutation always results in a single amino acid change.
Changes in the genetic sequence can have varying impacts on the resulting protein. While some substitutions change only one building block or have no effect at all, the addition or removal of nucleotides can disrupt the entire downstream reading frame. This leads to a wholesale change in the amino acid sequence from the point of mutation onwards, typically producing a non-functional product.

126. (A) P-2, Q-3, R-1, S-4
Biological systems involve various processes that are characterized by specific structures and regulatory elements. Genome duplication involves replicons and small fragments on the discontinuous strand. Transcription requires promoters and terminators to define the start and end of a gene. Translation uses triplets and their complements, while gene expression is controlled through organized clusters or distal regulatory elements in cells.

127. (A) The ability of the replication machinery to accurately copy the DNA template with very few errors.
The duplication of the genome is characterized by an extremely high degree of precision, ensuring that the genetic information is passed on without significant changes. This accuracy is achieved through the inherent selectivity of the polymerizing enzymes, active correction mechanisms during synthesis, and post-replication repair pathways. Together, these systems maintain the stability of the genetic code across many generations of cells.

128. (C) Statement I is correct but Statement II is incorrect.
Modern biotechnology allows for the creation of hybrid genetic molecules by combining sequences from different sources in a laboratory setting. This technological achievement is distinct from the natural exchange of genetic material that occurs during meiosis. While both involve new combinations of genes, the engineered process is a controlled and artificial method used for research, medicine, and industrial applications.

129. (B) TFIID, which contains the TATA-binding protein (TBP)
Starting the synthesis of ribonucleic acid in eukaryotic cells requires the organized assembly of numerous protein factors at the promoter. The process is initiated by the recognition of a

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enzymatic reactions. These downstream events eventually lead to the systematic breakdown of the cell, ensuring that the process is controlled.

113. (A) Both A and R are true and R is the correct explanation of A.
Repeated mating between close relatives results in a significant increase in the proportion of gene pairs that are identical. This shift in the genetic makeup of a population can lead to the emergence of harmful traits that were previously hidden in a heterozygous state. As these detrimental alleles become more frequent in a homozygous form, the overall health and productivity decline.

114. (B) A single origin of replication for the entire circular chromosome.
Bacterial genomes typically consist of a single, circular double-stranded molecule that undergoes duplication as one continuous functional unit. This process starts at a unique, designated site on the chromosome and proceeds in both directions until the entire circle is copied. Because the genome is relatively small and efficient, only one such starting point is necessary to complete replication rapidly.

115. (C) Uracil (U)
Chemical modifications to individual bases within a transcript can alter the genetic information without changing the underlying DNA sequence. One such modification involves the removal of an amino group from a specific base, which transforms it into a different base that is typically found in ribonucleic acid but not DNA. This change can create new functional signals or alter the protein.

116. (B) Promote the translocation of the ribosome along the mRNA.
During the cyclic addition of building blocks to a growing polypeptide chain, a specialized protein factor is required to move the translation machinery to the next position. This factor utilizes the energy from guanosine triphosphate to shift the ribosome exactly one triplet along the template. This ensures that the next codon is positioned correctly for the arrival of the subsequent amino acid.

117. (B) Using siRNAs or miRNAs to guide protein complexes to target mRNA.
Cells can selectively downregulate the expression of specific genes by targeting their messenger molecules for destruction or translational blockade. This process involves the use of small, non-coding sequences that provide high specificity through base pairing. By guiding enzyme complexes to complementary transcripts, the cell can effectively silence a gene after it has been transcribed, providing a powerful layer of regulation.

118. (A) B cells (or plasma cells)
The adaptive immune response utilizes specialized lymphocytes that are capable of identifying specific foreign antigens. When these cells are activated, they differentiate into a form that functions as a molecular factory, secreting large quantities of soluble proteins. These proteins circulate throughout the body, binding to pathogens and marking them for destruction by other components of the defense system, providing immunity.

119. (C) To show the linear order and distance between cleavage sites for different restriction enzymes on a DNA segment.
Physical diagrams of genetic material are essential for characterization and manipulation. By using various enzymes that cut at specific sequences and measuring the lengths of the resulting fragments, researchers can determine the relative locations of these sites. This map serves as a valuable reference for cloning, allowing for the precise insertion or removal of sequences during the creation of recombinant molecules.

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120. (D) The first AUG codon it encounters after the 5' cap.
In complex cells, the translation machinery identifies the start of a coding sequence by binding to the modified beginning of the transcript. The small subunit then moves along the molecule, essentially reading the sequence until it reaches the specific triplet that signals the start of protein synthesis. This scanning mechanism ensures that the ribosome correctly identifies the intended frame for translation.

immediate but generalized response to a wide range of threats, acting as a first line of defense. The other is slower to activate upon first exposure but develops highly specific recognition and a long-lasting memory of individual pathogens, allowing for a much more potent reaction during any subsequent encounters.

139. (C) Single-stranded DNA reassociates to form double-stranded DNA.
Measuring the kinetics of strand pairing provides information about the complexity and organization of a genome. In this technique, double-stranded genetic material is separated into single strands and then allowed to rejoin under controlled conditions. The rate at which complementary sequences find each other and reform double-stranded molecules is used to characterize the relative proportions of unique and repetitive sequences.

140. (A) Specialized structure at the end of a chromosome that prevents degradation.
Linear chromosomes possess specialized regions at their extremities that serve as protective caps. These structures consist of repetitive sequences and associated proteins that prevent the genetic material from being recognized as broken DNA and protect it from enzymatic degradation. They also play a critical role in solving the problem of incomplete synthesis at the very ends of the chromosome during duplication.

141. (D) Each nucleotide in the mRNA is part of only one codon.
The genetic code is interpreted in a precise and linear manner where the triplets are read sequentially. This property ensures that once the start site is identified, every individual base is included in exactly one triplet during the assembly of the polypeptide. This non-overlapping arrangement is fundamental to the accurate translation of the nucleotide sequence into a specific sequence of amino acids.

142. (B) 4, 2, 1, 3
The flow of biological information typically follows a standard pathway from the permanent storage form to the synthesis of functional molecules. This includes the duplication of the genome, the transcription of instructions into an intermediate molecule, and the translation of those instructions into proteins. In some cases, information can also move from an intermediate molecule back into a DNA form.

143. (C) To act as a structural and catalytic component of the ribosome.
A specific type of ribonucleic acid is a major constituent of the large complex responsible for protein synthesis. This molecule provides the structural framework for the complex and plays a direct role in the enzymatic formation of bonds between amino acids. Its presence is essential for the proper orientation of the messenger template and the adapter molecules during the translation process.

144. (D) The spread of cancer cells from the primary tumor to new locations in the body.
Malignant tumors are characterized by their ability to invade nearby tissues and move to distant sites within the organism. This process involves individual cells detaching from the original mass, traveling through the circulatory or lymphatic systems, and establishing new colonies in different organs. This movement is a critical stage in the progression of cancer and significantly complicates medical treatment.

145. (A) Determining the expression pattern of a specific gene within a tissue.
Visualization of the spatial distribution of genetic material or gene transcripts is achieved using labeled probes that are complementary to target sequences. This method is performed directly on preserved cells or thin layers of tissue. By observing where the probe binds, researchers can determine exactly which cells or cellular compartments contain the specific sequence of interest under various biological conditions.

146. (C) P-3, Q-2, R-4, S-1
Gene regulation occurs at multiple stages within the cell to ensure precise control over protein production. This includes modifications to the structure of the genetic material, variations in how transcripts are processed, and regulation of the translation machinery itself. Additionally, small molecules can target existing transcripts for silencing or degradation, providing a sophisticated system for fine-tuning the overall cellular response.

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structural components of bacterial cell walls or common motifs in viral genetic material. By targeting these conserved patterns, the system can provide a rapid and effective response to a wide range of infections.

165. (C) The sigma factor is required for termination.
In bacterial organisms, the process of synthesizing ribonucleic acid is initiated when a specific protein factor associates with the core enzyme to identify promoter sequences. However, once the process has begun, this factor is typically released. The conclusion of synthesis is instead determined by specialized sequences within the template or by the action of a different auxiliary protein that promotes transcript release.

166. (A) P-4, Q-1, R-3, S-2
Various specialized enzymes work together to ensure accurate genome duplication and repair. One enzyme removes temporary primers and fills in the gaps, while another physically separates the two strands of the helix. A third enzyme joins the resulting fragments together by sealing the backbone, and a fourth creates the initial short sequences necessary to start the synthesis of new DNA.

167. (B) 5' to 3' direction
The translation machinery moves along the messenger molecule in a specific and unidirectional manner. This movement ensures that the instructions encoded in the triplets are interpreted in the correct order, from the modified starting end towards the trailing end. This linear progression is essential for the accurate assembly of the amino acid sequence that forms the functional protein product.

168. (A) Both Statement I and Statement II are correct.
Cells can die through two very different pathways. One is a highly regulated and systematic process of self-disassembly that is essential for normal growth and development. The other is a messy and uncontrolled process resulting from severe injury, which leads to the release of cellular contents and triggers an inflammatory response in the surrounding tissue. Both are fundamental to understanding pathology.

169. (A) They are DNA-binding proteins that modulate the rate of transcription initiation.
Gene expression is precisely controlled by proteins that interact with specific regulatory sequences. These molecules can either facilitate the assembly of the transcription machinery at the promoter or obstruct its progress. By acting as molecular switches, these proteins allow the cell to adjust the production of different proteins in response to developmental cues or various signals from the surrounding environment.

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170. (D) Y-DNA
While the double helix can adopt several different structural conformations depending on hydration levels and sequence composition, only certain forms are recognized and characterized in detail. These include the standard biological form, a more compact form found in dehydration, and a left-handed configuration. Other proposed labels do not correspond to established and distinct physical models of the double-helical structure.

171. (D) 1, 2 and 3
The creation of hybrid genetic molecules involves several key steps and specialized tools. It requires enzymes to cut DNA at specific sites and another enzyme to join different fragments together. A vehicle, such as a small circular piece of DNA, is also needed to carry the foreign sequence into a host cell where it can be replicated and studied.

172. (B) Organismal complexity is not correlated with genome size.
Genomic studies reveal that the total amount of DNA in a haploid genome does not necessarily reflect the physiological or morphological complexity of a particular organism. This observation highlights how large portions of eukaryotic genomes consist of non-coding sequences and repetitive elements, rather than just functional protein-coding genes that determine the biological complexity of the species in the natural world.

173. (A) Both A and R are true and R is the correct explanation of A.
The system used by cells to translate genetic information into proteins is remarkably consistent across the entire tree of life. With very few minor exceptions in certain organelles or specialized organisms, the same nucleotide triplets represent

machinery to synthesize the necessary enzymes for the pathway.

156. (C) Spliceosome
In eukaryotic cells, the removal of non-coding regions from initial transcripts is mediated by a large complex of proteins and specialized ribonucleic acid molecules. This structure accurately identifies the boundaries of the non-coding segments, excises them, and joins the remaining coding regions together. This processing is essential for the production of a mature messenger molecule that can be correctly translated.

157. (B) Direct the ribosome-mRNA-polypeptide complex to the endoplasmic reticulum.
Many newly synthesized proteins are targeted to specific cellular locations or the secretory pathway. This is achieved by a short sequence of amino acids at the beginning of the chain that acts as a signal. specialized factors recognize this sequence and guide the entire translation complex to the membrane of a specific organelle, ensuring that the protein is correctly localized.

158. (B) Generate new combinations of genes, contributing to phage evolution.
Viruses that infect bacteria can exchange genetic material when multiple viruses occupy the same host. This process allows for the creation of new genetic arrangements, which can lead to the emergence of novel traits and increased adaptability. This exchange is a fundamental mechanism driving the evolution of these organisms and contributes to the overall genetic diversity within viral populations.

159. (B) Both alleles
Certain genes function as critical regulators that prevent uncontrolled cell growth and division. To completely lose this protective effect, both copies of the gene must typically be inactivated. This often occurs through a combination of an inherited mutation in one copy and a subsequent somatic mutation in the second copy, leading to a loss of the brake on the cell cycle.

160. (B) To form a permanent phosphodiester bond between the DNA insert and the vector.
In molecular cloning, it is essential to physically link two different genetic fragments into a single continuous molecule. An enzyme facilitates this by catalyzing the formation of a chemical bond between the sugar and phosphate groups of the adjacent ends. This stable connection allows the resulting recombinant molecule to be successfully introduced into and replicated within a host organism.

161. (C) Selective export of mature mRNAs via the nuclear pore complex.
The movement of mature transcripts from their site of synthesis to the translation machinery is a highly controlled process. It requires the interaction between the RNA-protein complex and specialized transport factors. These factors guide the molecules through large channels that span the double membrane surrounding the genetic material. This ensures that only correctly processed and functional transcripts reach the cytoplasm.

162. (A) A release factor binds to the stop codon in the A site, leading to hydrolysis of the polypeptide from the tRNA.
The synthesis of a polypeptide chain is concluded when the translation machinery encounters a specific triplet sequence that does not correspond to an amino acid. Specialized proteins then bind to the ribosome and catalyze the chemical release of the completed chain. This final step also triggers the disassembly of the complex, making the components available for a new round of translation.

163. (B) An increase in the expression of recessive traits, both beneficial and deleterious.
Repeated mating between close relatives results in a significant increase in the proportion of gene pairs that are identical. This shift in the genetic makeup of a population can lead to the emergence of traits that were previously hidden in a heterozygous state. While some effects may be neutral, the increased manifestation of harmful recessive alleles often results in reduced vigour.

164. (C) Conserved structures on pathogens like flagellin or lipopolysaccharide.
The immediate defense system identifies invaders by recognizing molecular features that are common to many types of microorganisms but absent in the host. These features include

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147. (C) To relieve the torsional stress and supercoiling created by DNA unwinding.
As the double helix is separated to allow for duplication, the physical twisting of the strands creates significant tension further along the molecule. specialized enzymes are required to manage this stress by introducing temporary breaks in one or both strands, allowing them to rotate and untwist. This prevention of excessive tangling is essential for the continued progress of the replication machinery.

148. (D) Statement I is incorrect but Statement II is correct.
Changes in the genetic sequence do not always result in a loss of function or harmful effects. Because the genetic code is redundant, some substitutions do not alter the resulting amino acid sequence, and the protein remains identical. Furthermore, while many mutations are detrimental, some can be neutral or even beneficial, providing the raw material for evolutionary adaptation and biological diversity.

149. (C) A protein called a release factor.
The synthesis of a polypeptide chain is concluded when the translation machinery encounters a specific triplet sequence that does not correspond to an amino acid. specialized proteins then bind to the ribosome and catalyze the chemical release of the completed chain. This final step also triggers the disassembly of the complex, making the components available for a new round of translation.

150. (B) Approximately 10.5 base pairs per turn
The most common conformation of the double helix under physiological conditions is a right-handed structure with specific dimensions. It features two distinct grooves of unequal width, which provide varying levels of access to the nitrogenous bases for regulatory proteins. The vertical distance required for the helix to complete one full rotation is typically occupied by slightly more than ten nucleotide pairs.

151. (B) 1 and 2 only
Eukaryotic transcripts undergo significant modifications before they are exported to the cytoplasm. One essential change involves the addition of a modified nucleotide to the start of the molecule during early synthesis. This modification serves multiple purposes, including shielding the transcript from enzymatic degradation and acting as a critical recognition signal for the ribosome to begin the translation of the genetic code.

152. (B) Masking of deleterious recessive alleles from parents in the hybrid.
One major theory explaining the increased vigour seen in hybrid offspring focuses on the interaction between different alleles at the same locus. Inbred parental lines often carry harmful recessive traits that are expressed due to homozygosity. When these lines are crossed, the offspring receive a functional dominant allele from one parent that compensates for the defective allele from the other, improving health.

153. (A) Both A and R are true and R is the correct explanation of A.
Genomic studies reveal that the total amount of DNA in a haploid genome does not necessarily reflect the physiological or morphological complexity of a particular organism. This observation highlights how large portions of eukaryotic genomes consist of non-coding sequences and repetitive elements, rather than just functional protein-coding genes that determine the biological complexity of the species in question.

154. (A) The presentation of antigen by an antigen-presenting cell (APC) to a helper T cell.
The activation of the specific defense system requires a multi-step process where foreign markers are identified and displayed. specialized cells ingest pathogens and present their fragments on the surface using major histocompatibility molecules. This display is recognized by regulatory lymphocytes, which then trigger the proliferation and activation of other immune cells, leading to a robust and targeted response.

155. (B) It acts as an inducer, binding to the repressor protein and inactivating it.
In certain metabolic pathways, the presence of a specific substrate can trigger the expression of the genes required for its breakdown. This occurs when a small molecule binds to a regulatory protein that is normally blocking transcription, causing the protein to change shape and detach from the DNA. This detachment allows the

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the same amino acids in bacteria, plants, and animals. This common language is a powerful piece of evidence for the shared evolutionary history of life.

174. (B) Splicing
In eukaryotic cells, the initial transcript contains both coding and non-coding sequences. To produce a functional messenger molecule, a large complex made of ribonucleic acids and proteins must accurately identify and remove the non-coding regions. Once these segments are excised, the remaining coding sequences are precisely linked together. This processing is essential for the subsequent synthesis of a functional protein.

175. (C) 16S rRNA of the small subunit
Starting protein synthesis in bacteria requires the precise positioning of the translation machinery on the messenger template. This is achieved by the interaction between a specific sequence upstream of the start codon and a complementary sequence within a component of the small ribosomal subunit. This base pairing ensures that the start codon is correctly placed in the entry site for translation.

176. (B) An N-terminal presequence that forms an amphipathic helix.
Directing proteins to the internal matrix of an organelle like the mitochondrion requires a specific signal at one end of the polypeptide. This signal typically forms a characteristic structure that is recognized by receptors on the organelle's surface. specialized transport complexes then facilitate the translocation of the protein across both the outer and inner membranes to its final functional location.

177. (B) Regulation of gene expression through chromatin remodeling and histone modification.
Complex organisms have evolved sophisticated methods for controlling gene access by altering the packaging of genetic material. By adding or removing chemical groups to the proteins around which DNA is wrapped, the cell can switch regions between an accessible and an inaccessible state. This epigenetic mechanism allows for long-term and stable changes in gene expression that are unique to eukaryotes.

178. (A) Choose between a lytic and a lysogenic life cycle.
Certain viruses that infect bacteria have the ability to adopt two different survival strategies. They can either immediately replicate and burst the host cell or integrate their genetic material into the host's chromosome and persist in a latent state. The choice between these pathways often depends on the environmental conditions and the overall health of the bacterial host cell.

179. (C) To produce genetically uniform, homozygous lines that can be used for creating predictable F1 hybrids.
Agricultural improvement often involves the creation of parental stocks that are genetically identical at almost all positions. These lines are developed through repeated self-pollination over many generations. While they may exhibit reduced vigour themselves, their extreme uniformity makes them ideal for producing first-generation hybrids with predictable and superior characteristics when crossed with another distinct and similarly uniform inbred line.

180. (B) DNA damage
Certain proteins act as critical checkpoints to maintain the integrity of the genome. When a cell sustains damage or undergoes abnormal stress, these proteins can temporarily halt the division process to allow for repairs. If the damage is too severe, they trigger a pathway that leads to the safe elimination of the cell, thereby preventing the transmission of mutations and development of cancer.

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181. (B) It synthesizes DNA from an RNA template.
Certain viruses utilize a specialized enzyme to convert their genetic information from a ribonucleic acid intermediate into a permanent deoxyribonucleic acid form. This unusual process reverses the typical flow of information and allows the viral sequence to be integrated into the host's genome. This capability is central to the life cycle of these viruses and is used in various biotechnology applications.

182. (A) Results in the substitution of one amino acid for another in the protein.
A point mutation that alters a single triplet can change the meaning of that triplet so that it represents a different building block. This results

in the production of a protein where one amino acid has been replaced by another. Depending on the location and chemical nature of the change, this can have effects ranging from negligible to severe on protein function.

183. (C) Removal of exons
The transition from an initial transcript to a mature messenger molecule in complex cells involves several specific steps. This includes adding a protective cap and a long tail to the ends, as well as the excision of non-coding sequences that do not contribute to the final protein. The coding segments themselves are joined together and are essential components of the functional messenger.

184. (B) Attach the correct amino acid to its corresponding tRNA.
The preparation of adapter molecules for protein synthesis involves the energy-dependent attachment of an amino acid to a specific ribonucleic acid molecule. This reaction is catalyzed by a highly selective enzyme that recognizes both the correct amino acid and its corresponding carrier. This link ensures that the translation machinery can accurately incorporate each block into the growing polypeptide chain according to instructions.

185. (A) It can remember and respond more effectively to a pathogen it has encountered before.
The complex defense system found in higher vertebrates is defined by its ability to recognize and respond to unique molecular features of individual pathogens. Unlike more generalized responses, this system develops a long-lasting record of previous encounters, allowing for a much faster and more robust reaction if the same threat returns. This capability is the fundamental biological principle underlying vaccination.

186. (A) P-3, Q-1, R-4, S-2
Various biological concepts describe mechanisms of disease, development, and genetic exchange. Some genes have the potential to cause cancer when mutated, while programmed cell death is essential for shaping tissues. The superiority of a hybrid over its parents is a key principle in agriculture, and the movement of genetic material mediated by a virus is a major pathway for bacterial diversity.

187. (A) Multiple replicons that activate sequentially during S phase.
Large eukaryotic genomes are divided into numerous functional units that undergo duplication independently. This organization is necessary because the total amount of genetic material is too large to be copied from a single starting point. Instead, replication begins at many different locations along each chromosome, with different units activating at specific times throughout the synthesis phase of the cell cycle.

188. (C) Statement I is correct but Statement II is incorrect.
Horizontal gene transfer in bacteria is facilitated by a mechanism that involves the direct movement of DNA between two adjacent cells. This process is dependent on the formation of a temporary bridge that physically links the donor to the recipient. While plasmids are commonly moved, this process can also involve the transfer of chromosomal segments if the plasmid is integrated into the genome.

189. (C) An insertion or deletion of one or two nucleotides.
Genetic information is interpreted in sets of three bases, meaning any addition or removal of nucleotides that is not a multiple of three will disrupt the entire downstream reading pattern. This type of mutation typically results in a completely different sequence of amino acids and often introduces a premature termination signal, leading to the production of a non-functional or truncated protein product.

190. (A) It is a less condensed form of chromatin that is generally accessible to transcription machinery.
Within the eukaryotic nucleus, genetic material exists in various states of compaction that directly influence its functional accessibility. The less condensed regions are typically rich in genes that are being actively expressed or are poised for expression. This open configuration allows transcription factors and the polymerase machinery to bind easily to the DNA templates, facilitating the synthesis of messenger ribonucleic acid.

191. (B) 1 and 2 only
Cells can downregulate the expression of specific genes at different stages of the information flow.

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This can be achieved either by making the DNA inaccessible to the transcription machinery through chemical modifications or by targeting the resulting transcripts for degradation using small RNA molecules. These mechanisms provide a powerful way to control protein levels without permanently altering the underlying genomic sequence.

192. (A) A site to the P site.
During the cyclic addition of building blocks to a growing polypeptide chain, a specialized protein factor is required to move the translation machinery to the next position. This factor utilizes energy to shift the ribosome exactly one triplet along the template. This movement causes the molecule carrying the growing chain to move from the entry site to the central processing site.

193. (A) Both A and R are true and R is the correct explanation of A.
The organization of genetic information differs significantly between simple and complex cells. In eukaryotes, a single messenger molecule typically contains the instructions for the synthesis of only one specific polypeptide. This is in contrast to many bacterial transcripts, which can carry the information for several different proteins that are often part of the same metabolic pathway or functional group.

194. (A) Chromosomal location or tissue expression of a specific nucleic acid sequence.
Visualization of the spatial distribution of genetic material or gene transcripts is achieved using labeled probes that are complementary to target sequences. This method is performed directly on preserved cells or thin layers of tissue. By observing where the probe binds, researchers can determine exactly which cells or cellular compartments contain the specific sequence of interest under different biological conditions in the tissue.

195. (B) Masking deleterious recessive alleles and/or overdominance at loci.
One major theory explaining the increased vigour seen in hybrid offspring focuses on the interaction between different alleles at the same locus. Inbred parental lines often carry harmful recessive traits that are expressed due to homozygosity. When these lines are crossed, the offspring receive a functional dominant allele from one parent that compensates for the defective allele from the other, improving health.

196. (C) The ribosomal RNA (rRNA) in the large subunit.
A specific type of ribonucleic acid is a major constituent of the large complex responsible for protein synthesis. This molecule provides the structural framework for the complex and plays a direct role in the enzymatic formation of bonds between amino acids. Its presence is essential for the proper orientation of the messenger template and the adapter molecules during the translation process in cells.

197. (C) Mismatch Repair (MMR)
Even with high-fidelity duplication systems, errors can occasionally occur where the wrong base is incorporated into the new strand. specialized repair pathways scan the DNA immediately after replication to identify these mismatches. By distinguishing between the original and the newly synthesized strand, the system can excise the incorrect base and replace it with the correct one, maintaining genomic stability.

198. (C) mRNA
Different types of ribonucleic acid perform specialized roles in the flow of genetic information. One specific class of molecules serves as a temporary copy of the instructions found in the DNA. These molecules are exported to the cytoplasm, where they associate with the protein-synthesizing machinery and serve as the direct template for the assembly of the amino acid chain.

199. (B) A family of proteases that are key mediators of apoptosis.
Programmed cell death is orchestrated by a specialized group of enzymes that act as molecular scissors to dismantle the cell from within. These enzymes are typically produced as inactive precursors that are activated in response to specific death signals. Once triggered, they cleave vital structural and functional proteins, leading to the orderly breakdown and packaging of the cell into membrane-bound bodies.

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200. (A) The innate immune system
Biological organisms possess a primary layer of protection that operates from birth and provides a consistent response to a wide range of threats. This system does not adapt to specific pathogens but rather uses generalized mechanisms to identify and neutralize foreign invaders rapidly. This early response is critical for containing infections while the more specialized and slower adaptive systems are being activated.

201. (A) It is wider and shorter helix than B-DNA.
The physical structure of a double helix can vary significantly depending on its hydration level. Compared to the standard form, this alternative configuration is more compact and has a greater diameter. The nitrogenous bases are not perpendicular to the central axis but are instead tilted. This form is often observed in double-stranded ribonucleic acid and in DNA-RNA hybrid molecules during cellular processes.

202. (A) Facilitate the binding of aminoacyl-tRNA, translocation, and other steps of polypeptide chain elongation.
During the elongation phase of protein synthesis, several specialized protein factors are required to ensure the process continues efficiently and accurately. These factors facilitate the delivery of building blocks to the ribosome and utilize the energy from guanosine triphosphate to move the machinery along the template. Their coordinated action is essential for the rapid growth of the new polypeptide chain during translation.

203. (D) Tetracycline
Many antibiotics function by disrupting various stages of protein synthesis in bacteria. Some specific molecules bind to the smaller part of the ribosome and physically obstruct the entry of the carrier molecules that deliver the next amino acid. By preventing these building blocks from reaching their destination, the drug effectively stops the growth of the polypeptide chain and inhibits bacterial proliferation.

204. (A) The post-transcriptional modification of the nucleotide sequence of an RNA molecule.
In certain biological systems, the information encoded in a gene is not identical to the information finally translated into a protein. This discrepancy arises from processes that modify specific bases within the transcript after it has been synthesized. These changes, such as the conversion of one base to another, can create new start or stop signals and significantly alter the resulting protein.

205. (C) The uptake of naked DNA from the environment.
Bacteria can acquire new genetic information through different horizontal pathways. One involves the absorption of free DNA fragments from the environment, while another requires a viral intermediary that carries genetic material from one host to another. These mechanisms allow for the spread of beneficial traits like antibiotic resistance through a population without the need for direct cell-to-cell contact between cells.

206. (A) P-2, Q-3, R-1, S-4
Changes in the genetic sequence can have diverse impacts on the resulting protein product. Some substitutions have no effect due to the redundancy of the code, while others change a single building block or create an early stop signal. More drastic changes, such as the addition or removal of bases, disrupt the entire reading frame, leading to a completely different polypeptide.

207. (B) A mutated gene that contributes to the development of cancer.
Certain genes normally play essential roles in promoting cell growth and division. However, when these genes undergo specific alterations such as point mutations, chromosomal translocations, or amplification, they can become abnormally active. This permanent gain of function leads to uncontrolled cellular proliferation and the development of tumors, representing a critical step in the complex process of malignant transformation in tissues.

208. (A) Both Statement I and Statement II are correct.
The complex defense system found in higher vertebrates is defined by its ability to recognize and respond to unique molecular features of individual pathogens. Unlike more generalized responses, this system develops a long-lasting record of previous encounters, allowing for a much faster and more robust reaction if the same threat returns. This capability is the fundamental biological principle underlying modern vaccines.

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209. (C) Proofreading by DNA polymerase and post-replication mismatch repair.
The duplication of the genome is characterized by an extremely high degree of precision, ensuring that the genetic information is passed on without significant changes. This accuracy is achieved through the inherent selectivity of the polymerizing enzymes, active correction mechanisms during synthesis, and post-replication repair pathways. Together, these systems maintain the stability of the genetic code across many cellular generations.

210. (C) Transcribing genes that code for proteins (mRNAs) and some small RNAs.
Higher organisms possess multiple specialized enzymes for the synthesis of different types of ribonucleic acid. One specific enzyme is responsible for transcribing the vast majority of genes that provide the instructions for building proteins. It also handles the production of various small regulatory molecules that help control cellular processes, making it a central player in the expression of genetic information.

211. (B) 1 and 2 only
The mapping of codons to amino acids exhibits a specific redundancy where most amino acids are associated with multiple nucleotide triplets. This characteristic is functionally significant because it provides a buffer against certain types of mutations, particularly those occurring at the third position of a codon. Consequently, the same polypeptide can be synthesized even if the underlying DNA sequence undergoes small changes.

212. (C) Prenylation
After synthesis, many proteins are modified by the addition of chemical groups that help determine their final location or function. One specific modification involves the attachment of a hydrophobic lipid molecule to the polypeptide chain. This addition often helps anchor the protein to cellular membranes, allowing it to participate in signaling pathways or other processes that require precise localization.

213. (A) Both A and R are true and R is the correct explanation of A.
The separation of the genetic material from the rest of the cell by a double membrane allows for the temporal and spatial regulation of gene expression. Transcription and the subsequent processing of transcripts occur inside this membrane-bound compartment. The mature molecules are then exported to the cytoplasm for translation, providing many opportunities for regulation and quality control that are absent in simpler cells.

214. (B) Gene duplication and subsequent divergence.
The presence of multiple related sequences in a genome is often the result of an evolutionary process where an ancestral sequence is copied. Over many generations, the different copies accumulate mutations independently, allowing them to acquire new specialized roles or be expressed under different conditions. This mechanism is a primary driver of biological innovation and the expansion of functional diversity in organisms.

215. (B) Increase the stability of the mRNA and promote its translation.
After the synthesis of a eukaryotic transcript, the three-prime end undergoes a specific maturation step. An enzyme adds a long sequence of adenine nucleotides without following a DNA template. This modification is crucial for the stability of the messenger molecule, its export from the nucleus, and its efficient translation by the ribosomal machinery in the cytoplasm of the eukaryotic cell.

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216. (C) An F (fertility) plasmid.
Genetic exchange between bacterial cells often involves the transfer of an extrachromosomal, circular DNA molecule. This particular molecule contains the instructions for building a specialized appendage that facilitates physical contact with another cell. Cells that carry this genetic element can act as donors during conjugation, while those lacking it serve as recipients, eventually acquiring the ability to act as donors.

217. (A) Loosely packed structure allows access for transcription factors and RNA polymerase.
Within the eukaryotic nucleus, genetic material exists in various states of compaction that directly influence its functional accessibility. The less condensed regions are typically rich in genes that are being actively expressed or are poised for expression. This open configuration

process is usually interrupted before completion because of the large size of the chromosome and the fragility of the connection. As a result, only a segment of the genetic material is moved, and the recipient rarely receives the full sequence.

236. (C) The correct aminoacyl-tRNA synthetase.
Accurate translation depends on the precise recognition of carrier molecules by the enzymes that charge them with amino acids. This recognition is mediated by specific structural and chemical features of the carrier, which differentiate it from all others. These identity elements are essential for maintaining the fidelity of the genetic code, ensuring that each adapter is linked to its correct building block.

237. (B) Content
This specific term refers to the total amount of genetic material present in a haploid genome of an organism. While it was initially expected that this value would be proportional to the complexity of the species, genomic studies have shown that this is not always the case. This observation highlights the significant role of non-coding and repetitive sequences in eukaryotic genomes.

238. (C) Serves as the binding site for the repressor protein.
In many bacterial pathways, the expression of genes is controlled by a specific sequence located between the promoter and the coding region. This sequence acts as a docking site for a regulatory protein that can physically block the progress of the transcription machinery. When this protein is bound, the genes are not expressed, allowing the cell to conserve energy.

239. (A) Determining cells in a developing embryo where a specific gene is expressed.
Visualization of the spatial distribution of genetic material or gene transcripts is achieved using labeled probes that are complementary to target sequences. This method is performed directly on preserved cells or thin layers of tissue. By observing where the probe binds, researchers can determine exactly which cells or cellular compartments contain the specific sequence of interest under different biological embryo conditions.

240. (D) Proteasome
Cells maintain protein quality control by marking damaged or unnecessary molecules for destruction. This involves the covalent attachment of multiple copies of a small regulatory protein. Once a chain of these tags is formed, it is recognized by a large proteolytic complex that unfolds the protein and breaks it down into small peptides. This selective degradation is essential for regulating many processes.

241. (A) 3, 1, 2
The synthesis of ribonucleic acid follows a specific and orderly sequence of events. It begins with the assembly of the transcription machinery at a specific site on the DNA template. Once initiated, the enzyme moves along the strand, building the new transcript by adding complementary nucleotides. Finally, specific signals trigger the termination of synthesis and the release of the completed molecule.

242. (A) Left-handed double helix.
While most genetic material exists in a smooth, right-handed double helix, certain sequences can adopt a more angular and opposite-oriented structure. This form is characterized by a specific arrangement where the backbone appears to zigzag rather than curve gradually. This conformation is typically found in regions with high concentrations of alternating purine and pyrimidine bases and is influenced by the environmental conditions.

243. (A) Polyadenylation
After the synthesis of a eukaryotic transcript, the three-prime end undergoes a specific maturation step. An enzyme adds a long sequence of adenine nucleotides without following a DNA template. This modification is crucial for the stability of the messenger molecule, its export from the nucleus, and its efficient translation by the ribosomal machinery in the cytoplasm of the complex eukaryotic cell.

244. (B) Prokaryotic ribosomes bind to the Shine-Dalgarno sequence, while eukaryotic ribosomes typically scan from the 5' cap.
Starting protein synthesis involves different strategies for identifying the correct start site. Simpler cells rely on a specific sequence within the transcript to position the machinery. In

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discontinuous strand. Transcription requires specialized factors to define the start of a gene. Translation uses specific sequences for ribosome assembly, while the processing of transcripts is controlled by large complexes that remove non-coding segments from the molecules.

227. (A) Most ribosomal RNA (rRNA) precursors
Higher organisms possess multiple specialized enzymes for the synthesis of different types of ribonucleic acid. One enzyme is dedicated to producing the large ribosomal components within a specialized nuclear region known as the nucleolus. These molecules form the structural and catalytic core of the machinery responsible for protein synthesis, and their continuous production is essential for cellular growth and function.

228. (A) Both Statement I and Statement II are correct.
After a polypeptide chain has been synthesized, it can undergo various chemical changes that alter its function, stability, or location. These modifications include the addition of phosphate or sugar groups, as well as alterations to the proteins that package the genetic material. Such changes are essential for regulating enzyme activity, signaling pathways, and the overall organization of the complex eukaryotic cell.

229. (C) Ribosome
The assembly of amino acids into a functional protein occurs on a large complex composed of both ribonucleic acids and numerous proteins. This complex accurately interprets the instructions carried by messenger molecules and facilitates the formation of bonds between the individual building blocks. These structures can be found either free in the cytoplasm or attached to internal membrane systems within the cell.

230. (C) Internal signals like DNA damage or external death receptor ligands.
The decision to undergo systematic cellular suicide can be triggered by a variety of cues. Internal monitoring systems can detect severe damage to the genome or metabolic stress, while specialized receptors on the cell surface can receive signals from other parts of the organism. Both pathways activate a cascade of proteases that dismantle the cell in an orderly fashion.

231. (D) 1, 2 and 3
During the process of genome duplication, a specific structure forms as the two strands of the parent molecule are pulled apart. This separation is necessary because the polymerizing enzymes require access to single-stranded templates to build new complementary strands. The movement of this structure along the DNA allows for the continuous and discontinuous synthesis of the new material in a specific direction.

232. (C) Helix-turn-helix
Proteins that regulate gene expression often possess specific structural arrangements that allow them to interact precisely with the double helix. These motifs typically consist of specific secondary structures that fit into the grooves of the DNA molecule, enabling the protein to recognize and bind to unique nucleotide sequences. This high degree of specificity is essential for the accurate control of transcription.

233. (A) Both A and R are true and R is the correct explanation of A.
Eukaryotic organisms can generate a diverse range of proteins from a relatively limited number of genes. This is achieved by varying the selection of coding sequences included in the final mature transcript. By joining different combinations of segments, a single gene can produce multiple protein variants with distinct functions or properties, significantly expanding the overall complexity and proteomic versatility.

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234. (A) Tumor suppressor genes inhibit cell division, while proto-oncogenes promote it.
The regulation of the cell cycle depends on a balance between opposing factors. Some genes produce proteins that drive proliferation and are essential for growth, while others act as critical brakes to prevent uncontrolled division. Mutations that overactivate the growth-promoting genes or inactivate the inhibitory ones can both contribute to the development of cancer by disrupting this delicate balance.

235. (A) Transfer of a segment of the bacterial chromosome, with the recipient usually remaining F-.
When a bacterium with an integrated fertility factor mates with another cell, it attempts to transfer its entire chromosome. However, the

masked in a heterozygous state will pair up. When these alleles become homozygous, they manifest as reduced fitness, decreased fertility, and poor overall health, a biological phenomenon that is common in many different populations.

254. (B) Lysogeny
Certain viruses that infect bacteria have the ability to integrate their genetic material into the host's chromosome and persist in a latent state. The viral DNA is then copied along with the bacterial genome every time the cell divides. This allows the virus to remain hidden within a population until environmental conditions trigger its activation and subsequent replication.

255. (C) Differentiate into plasma cells and produce antibodies.
The adaptive immune response utilizes specialized lymphocytes that are capable of identifying specific foreign antigens. When these cells are activated, they differentiate into a form that functions as a molecular factory, secreting large quantities of soluble proteins. These proteins circulate throughout the body, binding to pathogens and marking them for destruction by other components of the defense system in cells.

256. (A) A process that results in the downregulation of gene expression, either at the transcriptional or post-transcriptional level.
Cells can selectively downregulate the expression of specific genes at different stages of the information flow. This can be achieved either by making the DNA inaccessible to the transcription machinery through chemical modifications or by targeting the resulting transcripts for degradation using small RNA molecules. These mechanisms provide a powerful way to control protein levels without permanently altering the genomic sequence.

257. (C) It provides energy for the binding of aminoacyl-tRNA and for the translocation of the ribosome.
During the elongation phase of protein synthesis, several specialized protein factors are required to ensure the process continues efficiently and accurately. These factors facilitate the delivery of building blocks to the ribosome and utilize the energy from a specific high-energy nucleotide to move the machinery along the template. Their coordinated action is essential for the rapid growth of the polypeptide.

258. (C) Caspase-3
Programmed cell death is orchestrated by a specialized group of enzymes that act as molecular scissors to dismantle the cell from within. These enzymes are typically produced as inactive precursors that are activated in response to specific death signals. Once triggered, they cleave vital structural and functional proteins, leading to the orderly breakdown and packaging of the cell into membrane-bound bodies.

259. (B) Shows the location of suitable sites for inserting a foreign DNA fragment.
Physical diagrams of genetic material are essential for characterization and manipulation. By using various enzymes that cut at specific sequences and measuring the lengths of the resulting fragments, researchers can determine the relative locations of these sites. This map serves as a valuable reference for cloning, allowing for the precise insertion or removal of sequences during the creation of recombinant DNA.

260. (B) Multiple codons can code for the same amino acid.
The mapping of codons to amino acids exhibits a specific redundancy where most amino acids are associated with multiple nucleotide triplets. This characteristic is functionally significant because it provides a buffer against certain types of mutations, particularly those occurring at the third position of a codon. Consequently, the same polypeptide can be synthesized even if the underlying DNA sequence undergoes changes.

261. (B) It unwinds the DNA double helix at the replication fork.
During the process of genome duplication, a specialized enzyme is required to separate the two strands of the parent molecule. This separation is necessary because the polymerizing machinery requires access to single-stranded templates to build new complementary strands. The movement of this enzyme along the DNA allows for the continuous synthesis of the new material, forming the Y-shaped replication fork.

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contrast, complex cells typically recognize the modified beginning of the molecule and then move along the sequence until they encounter the signal to begin translation. These different mechanisms reflect the overall organization of cells.

245. (A) To activate B-cells and cytotoxic T-cells.
The adaptive immune response utilizes specialized lymphocytes that coordinate the overall defense. These cells identify foreign antigens displayed by other cells and release chemical signals that trigger the proliferation and activation of both antibody-producing cells and cells that directly destroy infected targets. This central role is essential for a robust and effective response to various infections and diseases.

246. (A) P-3, Q-4, R-1, S-2
Bacterial gene regulation involves various proteins and sequences that control the expression of metabolic pathways. Some proteins act to block transcription under certain conditions, while others facilitate it when specific energy sources are available. Fine-tuning of synthesis can also occur through sequences that cause early termination of the transcript, allowing the cell to rapidly adjust to its current metabolic needs.

247. (B) Highly repetitive sequences
Reassociation kinetics reveal the underlying organization and complexity of a particular genome. A higher value on the resulting curve indicates that the genetic material requires more time to find complementary partners, which is characteristic of unique sequences. In contrast, smaller values suggest a high degree of repetitiveness, where matching strands are present in many copies and rejoin quite rapidly.

248. (A) Both Statement I and Statement II are correct.
In eukaryotic cells, the initial transcript contains both coding and non-coding sequences. To produce a functional messenger molecule, a large complex made of ribonucleic acids and proteins must accurately identify and remove the non-coding regions. Once these segments are excised, the remaining coding sequences are precisely linked together. This processing is essential for the production of a mature messenger molecule.

249. (A) It protects the mRNA from 5' exonuclease degradation and facilitates ribosome binding.
Eukaryotic transcripts undergo significant modifications before they are exported to the cytoplasm. One essential change involves the addition of a modified nucleotide to the start of the molecule during early synthesis. This modification serves multiple purposes, including shielding the transcript from enzymatic degradation and acting as a critical recognition signal for the ribosome to begin the translation of the genetic instructions.

250. (A) Each daughter DNA molecule consists of one parental and one new strand.
The duplication of genetic material ensures that information is passed accurately to new cells. During this process, the two strands of the original molecule are separated and each serves as a template for the synthesis of a complementary partner. As a result, every resulting double-stranded molecule contains one original strand and one newly synthesized strand, maintaining the continuity of the genome.

251. (D) 1, 2 and 3
The protein-synthesizing machinery in cells is a large ribonucleoprotein complex composed of two distinct parts. One part is responsible for accurately decoding the messenger transcript by facilitating codon-anticodon interactions. The other part contains the catalytic site necessary for linking amino acids together into a chain. Together, these subunits ensure that the genetic information is efficiently and accurately converted into functional proteins.

252. (C) Translational level
Cells can control the rate of protein synthesis by modifying the activity of the factors involved in starting the translation process. For example, adding a phosphate group to a key factor can inhibit its ability to facilitate the assembly of the ribosome on the messenger template. This mechanism allows the cell to rapidly respond to stress or changes in the internal environment.

253. (C) A is true but R is false.
Mating between closely related individuals leads to a significant reduction in genetic variation within the offspring. This process increases the likelihood that rare, harmful alleles normally

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allows transcription factors and the polymerase machinery to bind easily to the DNA templates, facilitating the synthesis of functional messenger molecules.

218. (A) Heterosis (hybrid vigour)
When two genetically distinct inbred lines are crossed, the resulting first-generation offspring often display enhanced phenotypic characteristics compared to either parental line. This increased vigour can manifest as greater size, improved yield, or better resistance to environmental stressors. This phenomenon is extensively utilized in agricultural breeding programs to maximize the productivity and uniformity of various food and commercial plant crops.

219. (C) The cell cycle checkpoint in response to DNA damage.
Certain proteins act as critical checkpoints to maintain the integrity of the genome. When a cell sustains damage or undergoes abnormal stress, these proteins can temporarily halt the division process to allow for repairs. If the damage is too severe, they trigger a pathway that leads to the safe elimination of the cell, thereby preventing the transmission of mutations and development of cancer.

220. (B) The lysogenic cycle involves integration of the phage genome into the host chromosome, while the lytic cycle leads to immediate host cell lysis.
Certain viruses that infect bacteria have the ability to adopt two different survival strategies. They can either immediately replicate and burst the host cell or integrate their genetic material into the host's chromosome and persist in a latent state. The choice between these pathways often depends on the environmental conditions and the overall health of the bacterial host cell in the environment.

221. (B) 2, 3, 1
The body's defense system features a hierarchy of responses that activate at different times. The first line consists of physical and chemical barriers that are always present. If these are breached, an immediate but generalized internal response provides protection within hours. Finally, a highly specific and potent system develops over several days, creating a targeted attack and a long-lasting memory.

222. (A) A single tRNA can recognize multiple codons.
The rules governing base pairing are not identical at every position during the translation of the genetic code. While the first two positions require strict adherence to standard rules, the interaction at the third position of the triplet is more permissive. This flexibility allows a single adapter molecule to recognize several different codons that represent the same amino acid, increasing efficiency.

223. (B) It repairs pyrimidine dimers using energy from visible light.
Exposure to ultraviolet light can cause adjacent bases in a genetic sequence to bond abnormally, creating structural distortions. Some organisms possess a specialized enzyme that can directly reverse this damage without removing any nucleotides. This enzyme captures the energy from visible light to break the improper bonds, effectively restoring the original structure of the DNA molecule in a single enzymatic repair step.

224. (A) They are proteins that bind to specific DNA sequences to regulate transcription.
Gene expression is precisely controlled by proteins that interact with specific regulatory sequences. These molecules can either facilitate the assembly of the transcription machinery at the promoter or obstruct its progress. By acting as molecular switches, these proteins allow the cell to adjust the production of different proteins in response to developmental cues or various signals from the surrounding cellular environment.

225. (A) To release the completed polypeptide chain from the tRNA in the P site.
The synthesis of a polypeptide chain is concluded when the translation machinery encounters a specific triplet sequence that does not correspond to an amino acid. specialized proteins then bind to the ribosome and catalyze the chemical release of the completed chain. This final step also triggers the disassembly of the complex, making the components available for a new round of translation synthesis.

226. (A) P-3, Q-4, R-1, S-2
Biological systems involve various processes that are characterized by specific structures and regulatory elements. Genome duplication involves replicons and small fragments on the

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262. (C) Polyadenylation
Modifications occurring after the translation process are essential for determining the final structure and function of a polypeptide. Common changes include the addition of phosphate groups, carbohydrate chains, or small tagging proteins like ubiquitin. However, the removal of introns and the joining of exons, along with tail addition, occur at the ribonucleic acid level before the mature messenger RNA is translated.

263. (C) Specificity and memory
The complex defense system found in higher vertebrates is defined by its ability to recognize and respond to unique molecular features of individual pathogens. Unlike more generalized responses, this system develops a long-lasting record of previous encounters, allowing for a much faster and more robust reaction if the same threat returns. This capability is the fundamental biological principle underlying modern vaccines.

264. (C) An operon
In many bacterial genomes, genes that are involved in the same metabolic pathway are often organized into contiguous clusters. These groups are transcribed as a single messenger molecule and are controlled by a common regulatory region. This arrangement allows the cell to efficiently coordinate the production of related enzymes in response to changes in the environment, ensuring metabolic efficiency.

265. (B) The protein is truncated due to a premature stop codon.
A point mutation that results in the creation of a termination signal where a coding triplet should be can have drastic effects on the resulting protein. When the translational machinery reaches this signal, it stops synthesis prematurely. This typically leads to the production of a truncated polypeptide that lacks its functional domains and is often quickly degraded by the cell's systems.

266. (B) P-3, Q-2, R-1, S-4
Different helical conformations exist based on environmental conditions and sequence motifs. A-form DNA appears during dehydration, whereas B-form is the standard biological structure. Z-form DNA is characterized by a left-handed helix with a zigzagging backbone, often found in alternating purine-pyrimidine sequences. Lastly, genome duplication involves the discontinuous synthesis of short fragments on the lagging strand during the replication process.

267. (A) Causing the degradation of a specific target mRNA.
Cells can selectively downregulate the expression of specific genes by targeting their messenger molecules for destruction or translational blockade. This process involves the use of small, non-coding sequences that provide high specificity through base pairing. By guiding enzyme complexes to complementary transcripts, the cell can effectively silence a gene after it has been transcribed, providing a powerful layer of regulation.

268. (B) Both Statement I and Statement II are incorrect.
Genomic studies reveal that the total amount of DNA in a haploid genome does not necessarily reflect the physiological or morphological complexity of a particular organism. This observation highlights how large portions of eukaryotic genomes consist of non-coding sequences and repetitive elements, rather than just functional protein-coding genes that determine the biological complexity of the species in our world.

269. (B) Aminoacyl-tRNA synthetase
Accurate translation depends on the precise recognition of carrier molecules by the enzymes that charge them with amino acids. This recognition is mediated by specific structural and chemical features of the carrier, which differentiate it from all others. These identity elements are essential for maintaining the fidelity of the genetic code, ensuring each adapter is linked to its correct building block in the cell.

270. (B) Crossing two genetically diverse inbred parental lines to produce a superior F1 hybrid.
When two genetically distinct inbred lines are crossed, the resulting first-generation offspring often display enhanced phenotypic characteristics compared to either parental line. This increased vigour can manifest as greater size, improved yield, or better resistance to environmental stressors. This phenomenon is extensively utilized in agricultural breeding programs to

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maximize the productivity and uniformity of various food and commercial crops.

271. (B) 1 and 2 only
Initiation of the transcription process in complex cells requires the coordinated action of many protein factors that help the machinery recognize the correct starting location. These factors facilitate the assembly of a large complex at the promoter, which then unwinds the DNA to allow for synthesis. This process is highly regulated and occurs within a specific membrane-bound organelle.

272. (A) To carry a foreign piece of DNA into a host cell for replication.
In molecular cloning, it is necessary to have a vehicle that can carry a specific genetic fragment into a host organism where it can be copied. These vehicles are often small, circular DNA molecules that possess their own origin of replication and selectable markers. By inserting the target sequence into this vehicle, researchers can amplify and study the gene.

273. (A) Both A and R are true and R is the correct explanation of A.
During the process of genome duplication, the two strands of the parent molecule are oriented in opposite directions. Because the primary synthesis enzyme can only add nucleotides to one end of a growing chain, the two new strands must be built using different strategies. One strand is produced continuously, while the other is synthesized as a series of short segments.

274. (B) Telomerase
Linear chromosomes possess specialized regions at their extremities that serve as protective caps. These structures consist of repetitive sequences and associated proteins that prevent the genetic material from being recognized as broken DNA. specialized enzymes are required to solve the problem of incomplete synthesis at the very ends of the chromosome during duplication by extending these repetitive sequences using an internal template.

275. (A) A promoter, an operator, and one or more structural genes.
In many bacterial genomes, genes that are involved in the same metabolic pathway are often organized into contiguous clusters. These groups are transcribed as a single messenger molecule and are controlled by a common regulatory region and docking sites for proteins. This arrangement allows the cell to efficiently coordinate the production of related enzymes in response to changes in the environment.

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276. (D) Binding of a death ligand to a death receptor on the cell surface.
The decision to undergo systematic cellular suicide can be triggered by external cues. specialized receptors on the cell surface can receive signals from other parts of the organism, indicating that the cell is no longer needed or is potentially harmful. These binding events activate a cascade of proteases that dismantle the cell in an orderly fashion, ensuring tissue homeostasis.

277. (A) The aminoacyl-tRNA synthetase
Accurate translation depends on the precise recognition of carrier molecules by the enzymes that charge them with amino acids. This recognition is mediated by specific structural and chemical features of the carrier, which differentiate it from all others. These identity elements are essential for maintaining the fidelity of the genetic code, ensuring that each adapter is linked to its correct building block.

278. (A) Addition of a 5' cap
Eukaryotic transcripts undergo significant modifications before they are exported to the cytoplasm. One essential change involves the addition of a modified nucleotide to the start of the molecule during early synthesis. This modification serves multiple purposes, including shielding the transcript from enzymatic degradation and acting as a critical recognition signal for the ribosome to begin the translation of the instructions.

279. (C) Conjugation
Horizontal gene transfer in bacteria is facilitated by a mechanism that involves the direct movement of DNA between two adjacent cells. This process is dependent on the formation of a temporary bridge that physically links the donor to the recipient. The genetic information is then unidirectionally moved through this connection,

allowing the recipient to acquire new traits such as antibiotic resistance.

280. (A) Gain-of-function mutation.
Cancer development often involves alterations that cause a gene to become abnormally active. Unlike changes that destroy the function of a protein, these mutations increase its activity, make it resistant to regulation, or cause it to be produced in excessive amounts. Because only one altered allele is typically sufficient to drive uncontrolled cell growth, these mutations are considered dominant.

281. (B) A DNA or RNA molecule or a region of one that replicates as an autonomous unit.
A functional unit of genetic material that undergoes duplication as a single entity contains the specific sequences necessary to control the process. This includes a starting point where the replication machinery first assembles and initiates the unwinding of the double helix. Depending on the organism, it may also contain specific sequences that signal the end of the duplication process.

282. (D) The base pairs are tilted significantly from the helical axis.
The most prevalent form of the double helix under physiological conditions is a right-handed structure with specific geometric dimensions. It features two distinct grooves of unequal width, which provide varying levels of access to the nitrogenous bases for regulatory proteins. In this form, the nitrogenous bases are oriented almost perpendicular to the central axis, maximizing the stacking interactions between them.

283. (B) Bind to silencers and decrease or prevent transcription.
Gene expression can be actively inhibited by specialized proteins that interact with specific control regions in the DNA. These molecules can work by physically obstructing the attachment of the transcription machinery or by recruiting other factors that compact the local structure of the genetic material. By preventing the synthesis of messenger RNA, these proteins play a crucial role in the precise regulation.

284. (A) Transfer RNA (tRNA)
Protein synthesis requires a bridge between the nucleotide sequence of a messenger molecule and the amino acid sequence of a polypeptide. This role is filled by specialized ribonucleic acid molecules that carry a specific amino acid at one end and possess a complementary three-base sequence at the other. This dual functionality allows them to accurately position each block during translation.

285. (C) Polymerase III
In prokaryotic organisms, the primary enzyme responsible for the elongation of both the leading and lagging strands is a highly processive complex. It adds deoxyribonucleotides to the three-prime hydroxyl end of a growing primer or nascent strand. This specific enzyme complex ensures rapid and accurate genome duplication by working alongside other proteins at the replication fork during the cell division.

286. (A) P-4, Q-1, R-2, S-3
The body's defense mechanism utilizes various specialized cells to maintain health and eliminate pathogens. Some cells identify foreign markers to activate other parts of the system, while others are responsible for producing soluble proteins that target invaders. regulatory cells coordinate these activities, and cells that directly destroy host cells that have been compromised provide a targeted and effective defense.

287. (A) Removing the damaged base(s) and a segment of the DNA strand.
Repairing damage to the genetic material follows specific enzymatic pathways depending on the nature of the lesion. Many systems involve the precise removal of the affected region, followed by the synthesis of a new segment using the opposite strand as a template. Finally, an enzyme seals the remaining break in the backbone, restoring the integrity and stability of the sequence.

288. (A) Both Statement I and Statement II are correct.
The organization of genetic information differs significantly between simple and complex cells. In eukaryotes, a single messenger molecule typically contains instructions for only one specific polypeptide. This is in contrast to many bacterial transcripts, which can carry the information for several different proteins that

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are often part of the same metabolic pathway or functional group, increasing efficiency.

289. (A) Bind to the small ribosomal subunit and prevent its premature association with the large subunit.
Starting protein synthesis in bacteria requires the coordinated action of several protein factors. One specific factor binds to the smaller part of the ribosome and ensures it does not pair with the larger part until the messenger template and initiator carrier molecule are correctly positioned. This regulation is essential for the accurate identification of the start of a gene.

290. (A) Point mutation or gene amplification leading to increased activity.
Cancer development often involves alterations that cause a gene to become abnormally active. Unlike changes that destroy the function of a protein, these mutations increase its activity, make it resistant to regulation, or cause it to be produced in excessive amounts. Because only one altered allele is typically sufficient to drive uncontrolled cell growth, these mutations are dominant.

291. (D) 1, 2 and 3
When two genetically distinct inbred lines are crossed, the resulting first-generation offspring often display enhanced phenotypic characteristics compared to either parental line. This increased vigour can manifest as greater size or improved yield. However, this advantage is often reduced in subsequent generations as the unique genetic combinations begin to segregate, leading to a loss of uniformity and performance.

292. (D) Cell lysis and release of cellular contents causing inflammation.
Systematic cellular suicide is a vital biological process that allows for the removal of damaged or unnecessary cells during development and homeostasis. Unlike accidental cell death, this highly regulated pathway involves characteristic morphological changes such as cell shrinkage and nuclear fragmentation. Because the cell contents are neatly packaged into membrane-bound bodies, there is no leakage that triggers an inflammatory response.

293. (A) Both A and R are true and R is the correct explanation of A.
Gene expression is precisely controlled by proteins that interact with specific regulatory sequences. These molecules can either facilitate the assembly of the transcription machinery at the promoter or obstruct its progress. By acting as molecular switches, these proteins allow the cell to adjust the production of different proteins in response to developmental cues or various signals from the environment.

294. (A) They are the machinery that reads the mRNA and synthesizes the polypeptide chain.
The assembly of amino acids into a functional protein occurs on a large complex composed of both ribonucleic acids and numerous proteins. This complex accurately interprets the instructions carried by messenger molecules and facilitates the formation of bonds between individual building blocks. These structures are found in the cytoplasm and are essential for the conversion of genetic information.

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295. (D) Catabolite repression
Bacterial cells prioritize the use of energy-efficient carbon sources over others. When a preferred sugar is available, it triggers a regulatory mechanism that prevents the expression of genes required for metabolizing less efficient alternatives. This ensures that the cell does not waste resources synthesizing enzymes for a pathway it does not currently need, representing a classic metabolic efficiency example.

296. (B) Okazaki fragments
During the process of genome duplication, the two strands of the parent molecule are oriented in opposite directions. Because the primary synthesis enzyme can only add nucleotides to one end of a growing chain, the two new strands must be built using different strategies. One strand is produced continuously, while the other is synthesized as a series of short segments.

297. (B) Targeting the protein for degradation by the proteasome.
Cells maintain protein quality control by marking damaged or unnecessary molecules for destruction. This involves the covalent attachment of multiple copies of a small regulatory protein. Once a chain of these tags is formed, it is

recognized by a large proteolytic complex that unfolds the protein and breaks it down into small peptides. This selective degradation is essential for regulation.

298. (A) A stuck accelerator and faulty brakes.
The regulation of the cell cycle depends on a balance between opposing factors. Some genes produce proteins that drive proliferation and are essential for growth, while others act as critical brakes to prevent uncontrolled division. Mutations that overactivate the growth-promoting genes or inactivate the inhibitory ones can both contribute to the development of cancer by disrupting this delicate balance.

299. (A) The anticodon loop
The adapter molecule responsible for bringing building blocks to the ribosome contains a specific three-nucleotide sequence that is essential for decoding. This sequence interacts directly with the complementary triplets on the messenger template through base pairing. This precise interaction ensures each amino acid is incorporated into the growing polypeptide chain at the correct position according to the genetic instructions.

300. (B) T-cells of the adaptive immune system recognizing foreign MHC molecules.
When a tissue or organ is transplanted from one individual to another, the recipient's defense system may identify the foreign surface markers on the donor cells. specialized lymphocytes recognize these differences as a threat and mount a targeted response to destroy the transplanted tissue. This reaction is a specific manifestation of the body's ability to distinguish between self and non-self.

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atomic structure
(B) Scanning Electron Microscope - Surface morphology
(C) Fluorescence Microscope - Detection of specific molecules
(D) Transmission Electron Microscope - Internal ultrastructure

59. Cryofixation, used in preparing samples for electron microscopy, involves:
(A) treating the sample with chemical fixatives at low temperatures.
(B) embedding the sample in a plastic resin that hardens upon cooling.
(C) rapidly freezing the sample to preserve its structure in a near-native state.
(D) staining the sample with heavy metals at sub-zero temperatures.

60. Match List-I with List-II regarding laboratory instruments and their functions.
List I: (Laboratory Instrument)
P. Centrifuge
Q. Colorimeter
R. pH meter
S. Microtome
List II: (Primary Function)
1. Measures concentration of colored solutions
2. Measures hydrogen ion concentration
3. Slices thin sections of tissues
4. Separates components by density/mass
Choose the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

61. Which spectroscopic method relies on the absorption of radiofrequency radiation by atomic nuclei in a magnetic field?
(A) UV-Visible spectroscopy
(B) Fluorescence spectroscopy
(C) Electron Spin Resonance (ESR)
(D) Nuclear Magnetic Resonance (NMR)

62. The analysis of biomolecules using light scattering can provide information about their:
(A) isoelectric point.
(B) size and shape.
(C) amino acid sequence.
(D) enzymatic activity.

63. What is the fundamental principle of X-ray crystallography for structure determination?
(A) The absorption of X-rays by different atoms.
(B) The emission of fluorescence upon X-ray bombardment.
(C) The scattering of X-rays by the electron clouds of atoms in a crystal lattice.
(D) The change in polarization of X-rays after passing through the sample.

64. In mass spectrometry, what does MALDI stand for?
(A) Multiple-Angle Laser Desorption/ Ionization
(B) Mass-Analyzed Laser Dispersion/Ionization
(C) Matrix-Altered Liquid Desorption/ Ionization
(D) Matrix-Assisted Laser Desorption/ Ionization

65. Consider the following statements about spectroscopic techniques:
I. UV spectroscopy is used to quantify nucleic acids at a wavelength of 260 nm.
II. Circular Dichroism is effective for studying the secondary structure of proteins.
III. NMR can determine the 3D structure of small proteins in solution.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

66. Polyclonal antibodies are a heterogeneous mixture of immunoglobulins that:
(A) recognize multiple epitopes on a single antigen.
(B) are produced by a single clone of B-cells.
(C) recognize a single epitope on an antigen.
(D) are produced using recombinant DNA technology.

67. In an indirect ELISA, the molecule that is directly conjugated to an enzyme is:
(A) the antigen.
(B) the secondary antibody.
(C) the primary antibody.
(D) the substrate.

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Q. Phase contrast
R. SEM
S. Fluorescence microscopy

List II: (Primary Principle/Use)
1. Observing surface topography
2. Visualizing specific molecules with fluorochromes
3. Revealing internal cellular structures by fracturing a frozen specimen
4. Visualizing unstained cells based on refractive index differences

Choose the correct option:
(A) P-3, Q-4, R-1, S-2
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

9. The freeze-fracture method for electron microscopy is particularly useful for studying:
(A) the overall three-dimensional shape of a whole prokaryotic or eukaryotic cell.
(B) the specific sequence of nucleotide bases in a condensed chromosome.
(C) the arrangement of proteins within the lipid bilayer of cell membranes.
(D) the dynamic process of mitosis and cytokinesis occurring in living cells.

10. Which technique is used to enhance, analyze, and quantify features in images obtained from microscopes?
(A) Image processing
(B) Freeze-etching
(C) X-ray crystallography
(D) Spectrophotometry

11. Electrophoresis separates charged biomolecules based on their:
(A) differential solubility in an organic solvent.
(B) binding affinity to a stationary phase.
(C) ability to absorb ultraviolet light.
(D) rate of migration in an electric field.

12. Consider the following statements about Chromatography:
I. It is a technique used for separating mixtures.
II. It consists of a mobile phase and a stationary phase.
III. Separation is based on differential partitioning of components between the two phases.

Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

13. In a colorimeter, the amount of light absorbed by a colored solution is directly proportional to the concentration of the solute. This principle is known as the:
(A) Van't Hoff equation.
(B) Michaelis-Menten kinetics.
(C) Beer-Lambert Law.
(D) Henderson-Hasselbalch equation.

14. A pH meter measures the:
(A) temperature of a solution.
(B) electrical conductivity of a solution.
(C) viscosity of a solution.
(D) hydrogen ion activity in a solution.

15. The following steps are involved in differential centrifugation to separate cellular components:
I. Centrifuge at high speed (e.g., 100,000 x g) to pellet microsomes.
II. Centrifuge at low speed (e.g., 600 x g) to pellet nuclei.
III. Centrifuge at medium speed (e.g., 15,000 x g) to pellet mitochondria and chloroplasts.
IV. Start with a cell homogenate.

Which of the following is the correct chronological sequence?
(A) IV, III, II, I
(B) I, II, III, IV
(C) IV, II, III, I
(D) II, IV, I, III

16. What is the primary function of a microtome in a biology laboratory?
(A) To culture microorganisms in a sterile environment.
(B) To cut extremely thin slices of tissue for microscopy.
(C) To measure the pH of a solution very accurately.
(D) To separate macromolecules based on their size.

17. The purpose of a Laminar Air Flow cabinet is to:
(A) incubate cultures at a specific temperature

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CHAPTER 10

Tools Techniques in Biology and Biotechnology

1. Which microscopic technique is best suited for observing unstained, living cells by converting differences in refractive index into variations in light intensity?
(A) Dark field microscopy
(B) Phase contrast microscopy
(C) Fluorescence microscopy
(D) Transmission electron microscopy

2. Which of the following statements about Dark Field Microscopy is correct?
(A) It blocks direct light rays with a condenser so only scattered light enters the objective.
(B) It uses direct illumination to make the specimen appear bright against a dark background.
(C) It visualizes internal organelle structures at high resolution using an electron beam.
(D) It relies on staining specimens with specific fluorescent dyes to ensure visibility.

3. A researcher wants to visualize the specific location of a particular protein within a cell using a fluorescently-labeled antibody. Which microscopic technique would be the most appropriate choice?
(A) Phase contrast microscopy
(B) Scanning electron microscopy
(C) Fluorescence microscopy
(D) Differential interference contrast microscopy

4. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Electron microscopes provide much higher resolution than light microscopes.
Reason (R): The wavelength of electrons used in an electron microscope is much shorter than the wavelength of visible light.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

5. The primary function of a Scanning Electron Microscope (SEM) is to provide detailed images of:
(A) the internal ultrastructure of cells.
(B) the movement of molecules in a living cell.
(C) the surface topography of a specimen.
(D) the elemental composition of a sample using X-rays.

6. Given below are two statements:
Statement I: Transmission Electron Microscopy (TEM) produces a 2D projection image of a thin specimen.
Statement II: Scanning Electron Microscopy (SEM) scans the surface of a specimen with an electron beam to create a 3D-like image.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

7. Which of the following is NOT a common chemical fixative used for preparing samples for electron microscopy?
(A) Glutaraldehyde
(B) Osmium tetroxide
(C) Formaldehyde
(D) Ethanol

8. Match List-I with List-II regarding microscopic techniques and their principles.
List I: (Technique)
P. Freeze-etching

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DNA sequences on a chromosome.

27. The key difference between ELISA and Radioimmunoassay (RIA) is the:
(A) specific type of antigen being detected in the sample.
(B) origin of the primary antibody used in the procedure.
(C) solid phase material to which the target antigen is bound.
(D) type of label used for detection, such as enzymes or isotopes.

28. Western blotting is a technique used for the specific detection of:
(A) DNA sequences in a sample.
(B) Proteins in a sample.
(C) RNA sequences in a sample.
(D) Lipids in a sample.

29. Southern blotting, developed by Edwin Southern, is a method used to detect specific:
(A) protein sequences.
(B) RNA sequences.
(C) DNA sequences.
(D) carbohydrate modifications.

30. Match List-I with List-II regarding blotting techniques and the molecules they detect.
List I: (Blotting Technique)
P. Southern Blotting
Q. Northern Blotting
R. Western Blotting
S. Eastern Blotting
List II: (Molecule Detected)
1. Protein
2. Post-translational modifications
3. DNA
4. RNA
Choose the correct option:
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

31. Immunoprecipitation is a technique used to:
(A) isolate a specific protein from a complex mixture using a targeted antibody.
(B) sequence the primary amino acid chain of a protein using Edman degradation.
(C) determine the total molecular weight of a purified antibody via spectrometry.
(D) separate various DNA fragments by size through standard gel electrophoresis.

32. A researcher wants to sort and quantify different cell types from a mixed population based on their surface markers. Which technique is most suitable for this purpose?
(A) X-ray crystallography
(B) Flow cytometry
(C) Centrifugation
(D) Western blotting

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33. The technique that uses fluorescently labeled DNA probes to detect and localize specific DNA sequences on chromosomes is known as:
(A) Western Blotting analysis.
(B) Fluorescence In Situ Hybridization (FISH).
(C) Standard in situ localization methods.
(D) Targeted Immunoprecipitation techniques.

34. Genomic In Situ Hybridization (GISH) is primarily used to:
(A) distinguish between chromosomes from different parental species in a hybrid.
(B) identify specific genes within a single genome using targeted DNA probes.
(C) quantify the expression level of a particular RNA transcript in a sample.
(D) detect the presence of a specific protein in a fixed tissue section slide.

35. Consider the following statements regarding immunodetection techniques:
I. ELISA relies on an enzyme-conjugated antibody for signal generation.
II. Western blotting involves the transfer of proteins from a gel to a membrane.
III. Immunoprecipitation uses antibodies to purify antigens from a solution.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

36. Site-directed mutagenesis is a form of in vitro mutagenesis used to:
(A) create random mutations throughout a gene.
(B) delete an entire gene from an organism's

and humidity.
(B) provide a sterile work area free of particulate contamination.
(C) amplify DNA segments using temperature cycles.
(D) measure the absorbance of light by a sample.

18. UV spectroscopy is commonly used to quantify proteins and nucleic acids because:
(A) Aromatic amino acids and nucleotide bases absorb UV light at specific wavelengths.
(B) Targeted proteins and nucleic acids fluoresce naturally within the UV range.
(C) These molecules scatter UV light in a way that is highly concentration-dependent.
(D) Interaction with the sample causes a detectable change in UV light polarization.

19. Circular Dichroism (CD) spectroscopy is a biophysical method primarily used for:
(A) determining the elemental and chemical composition of a complex protein.
(B) determining the precise 3D atomic coordinates of a globular protein.
(C) determining secondary structure content like alpha-helices and beta-sheets.
(D) determining the total molecular weight and mass of a purified protein.

20. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Nuclear Magnetic Resonance (NMR) spectroscopy can be used to determine the three-dimensional structure of proteins in solution.
Reason (R): NMR provides information about the distances between specific atoms within a molecule.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

21. What information does Electron Spin Resonance (ESR) spectroscopy provide?
(A) The sequence of amino acids in a protein.
(B) The secondary structure of a biomolecule.
(C) The environment of unpaired electrons in a molecule.
(D) The molecular weight of a large polymer.

22. The most definitive method for determining the precise three-dimensional atomic structure of a crystallized biomolecule is:
(A) Circular Dichroism.
(B) X-ray crystallography.
(C) UV-Visible Spectroscopy.
(D) Mass Spectrometry.

23. Which of the following is an INCORRECT statement regarding mass spectrometry?
(A) It measures the mass-to-charge ratio of ions.
(B) It can be used to determine the molecular weight of a biomolecule.
(C) It can be used to identify proteins and sequence peptides.
(D) It requires the sample to be in a crystalline form.

24. Surface Plasmon Resonance (SPR) is a technique used to:
(A) analyze real-time biomolecular interactions.
(B) measure the thermal stability of a protein.
(C) determine the atomic structure of a molecule.
(D) separate molecules based on their charge.

25. The generation of antibodies for immunotechniques typically involves:
(A) synthesizing antibodies through chemical processes in a laboratory setting.
(B) isolating antibodies directly from the vascular tissues of specialized plants.
(C) injecting an antigen into an animal to trigger a specific immune response.
(D) using genetically modified bacteriophages to produce antibody fragments.

26. Which of the following statements correctly describes an Enzyme-Linked Immunosorbent Assay (ELISA)?
(A) It uses enzyme-linked antibodies to produce a color change for antigen detection.
(B) It is a biochemical technique for separating various proteins based on their size.
(C) It utilizes radioactively labeled antibodies to detect the presence of an antigen.
(D) It is a high-resolution method for visualizing

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(A) transformation.
(B) transcription.
(C) translation.
(D) ligation.

48. Given below are two statements:
Statement I: Genomic DNA libraries contain all the DNA sequences of an organism, including introns and regulatory regions.
Statement II: cDNA libraries contain only the coding sequences (exons) of genes that are being actively transcribed.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

49. Which vector is most suitable for cloning very large DNA fragments (hundreds of thousands of base pairs)?
(A) Yeast Artificial Chromosome (YAC)
(B) Bacteriophage lambda
(C) Plasmid
(D) Cosmid

50. The term 'recombinant protein' refers to a protein that is:
(A) naturally occurring in multiple organisms.
(B) produced from a cloned gene in a host system.
(C) chemically synthesized in a laboratory.
(D) a hybrid of two different natural proteins.

51. What is the primary purpose of PCR (Polymerase Chain Reaction)?
(A) To sequence an entire genome.
(B) To amplify a specific segment of DNA exponentially.
(C) To separate proteins based on their size.
(D) To insert a gene into a plasmid vector.

52. In agriculture, biotechnology has been used to develop plants with all the following traits EXCEPT:
(A) complete immunity to all physical damage.
(B) increased resistance to specific insects.
(C) improved nutritional and vitamin content.
(D) tolerance to common herbicide treatments.

53. DNA fingerprinting is a technique used to identify individuals based on:
(A) the sequence of their expressed genes.
(B) the shape of their chromosomes.
(C) variations in their repetitive DNA sequences.
(D) their blood type antigens.

54. The concept of Intellectual Property Rights (IPR) in biotechnology is primarily concerned with:
(A) ensuring the free and open sharing of all international scientific discoveries.
(B) regulating the ethical conduct of research involving various human subjects.
(C) standardizing laboratory safety protocols across different research countries.
(D) providing legal protection for inventions like gene sequences and GMOs.

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55. In the context of biotechnology, what does 'environmental biotechnology' primarily focus on?
(A) the study of how organisms interact with their natural ecological environment.
(B) the conservation of biodiversity through the use of cryopreservation methods.
(C) using biological systems for remediation of contaminated environments and waste.
(D) the genetic modification of animal models to study complex human diseases.

56. The use of microorganisms to produce yogurt and cheese is an application of biotechnology in which industry?
(A) Healthcare
(B) Food industries
(C) Forestry
(D) Agriculture

57. The use of phase plates in a phase contrast microscope is to:
(A) increase the magnification of the objective lens.
(B) filter out specific wavelengths of light.
(C) provide illumination from the side of the specimen.
(D) create a phase shift in the light passing through the specimen.

58. Which of the following is an INCORRECT pair?
(A) Phase Contrast Microscope - High resolution

genome.
(C) analyze the expression of all genes in a cell simultaneously.
(D) make specific, targeted changes to a DNA sequence.

37. The term "gene knock out" refers to a genetic technique in which:
(A) a gene's expression is temporarily silenced by RNAi.
(B) a copy of a gene is inserted to increase its expression.
(C) one of an organism's genes is made inoperative.
(D) a gene is tagged with a fluorescent protein.

38. Microarray-based techniques are primarily used for:
(A) determining the 3D structure of a single protein.
(B) large-scale analysis of gene expression.
(C) sequencing an entire genome.
(D) creating targeted deletions in a gene.

39. Which of the following is NOT a common method for the analysis of lipid molecules?
(A) Gas chromatography
(B) Thin-layer chromatography
(C) Mass spectrometry
(D) Sanger sequencing

40. Restriction Fragment Length Polymorphism (RFLP) analysis involves:
(A) digesting DNA with restriction enzymes and analyzing fragment size variations.
(B) amplifying segments of genomic DNA using random primers and PCR techniques.
(C) determining the complete sequence of an entire double-stranded DNA molecule.
(D) hybridizing the total genomic DNA extracted from two different animal species.

41. What is the main characteristic of Random Amplified Polymorphic DNA (RAPD) markers?
(A) They require prior knowledge of the DNA sequence.
(B) They use long, specific primers for amplification.
(C) They use short, arbitrary primers to amplify random DNA segments.
(D) They involve digesting DNA with restriction enzymes.

42. Amplified Fragment Length Polymorphism (AFLP) is a technique that combines elements of:
(A) RFLP and PCR.
(B) RAPD and FISH.
(C) Southern blotting and Western blotting.
(D) ELISA and RIA.

43. Which of the following is a common method for purifying plasmid DNA from a bacterial lysate?
(A) Phenol-chloroform extraction for proteins
(B) Differential centrifugation to pellet nuclei
(C) Affinity chromatography using an antigen column
(D) Alkaline lysis method

44. Two-dimensional (2D) gel electrophoresis separates proteins based on which two distinct properties?
(A) Overall solubility and molecular size.
(B) Isoelectric point and molecular weight.
(C) Net surface charge and hydrophobicity.
(D) Specific tertiary shape and particle size.

45. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): cDNA libraries represent only the expressed genes of a cell.
Reason (R): cDNA is synthesized from an mRNA template using the enzyme reverse transcriptase.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

46. Isoelectric focusing (IEF) is a method that separates proteins based on their:
(A) molecular weight.
(B) solubility in different solvents.
(C) overall charge in a pH gradient.
(D) affinity for a specific ligand.

47. The process of inserting a DNA fragment into a vector like a plasmid is known as:

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68. What is the purpose of the blocking step in techniques like ELISA and Western blotting?
(A) denaturing all target proteins immobilized on the membrane.
(B) preventing non-specific binding of antibodies to the solid support.
(C) activating the reporter enzyme conjugated to the detection antibody.
(D) washing away any unbound or excess antigens from the solid surface.

69. All of the following are required for a standard Western blot analysis EXCEPT:
(A) a reverse transcriptase enzyme.
(B) transfer of proteins to a membrane.
(C) a primary antibody specific to the target protein.
(D) SDS-PAGE.

70. The technique that allows for the detection and localization of specific mRNA molecules within a tissue section or whole organism is:
(A) immunoprecipitation.
(B) flow cytometry.
(C) in situ hybridization.
(D) RFLP analysis.

71. In flow cytometry, forward scatter (FSC) is an indicator of a cell's:
(A) internal complexity or granularity.
(B) DNA content.
(C) surface protein expression.
(D) size.

72. Gene knockout technology in eukaryotic organisms often utilizes which cellular process?
(A) Homologous recombination
(B) RNA interference
(C) Reverse transcription
(D) Apoptosis

73. A key advantage of AFLP over RAPD is that AFLP:
(A) does not require PCR.
(B) uses much longer primers.
(C) is more reproducible.
(D) does not require restriction enzymes.

74. The separation of proteins in SDS-PAGE (Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis) is primarily based on differences in their:
(A) molecular mass.
(B) native charge.
(C) isoelectric point.
(D) hydrophobicity.

75. The following vectors are used in recombinant DNA technology:
I. Plasmid
II. BAC (Bacterial Artificial Chromosome)
III. Cosmid
IV. YAC (Yeast Artificial Chromosome)
Which of the following represents the correct increasing order of their capacity to carry a foreign DNA insert?
(A) I, III, II, IV
(B) I, II, III, IV
(C) III, I, IV, II
(D) II, I, III, IV

76. The enzyme used to create a DNA copy from an RNA template is:
(A) DNA polymerase.
(B) Reverse transcriptase.
(C) RNA polymerase.
(D) DNA ligase.

77. Which of the following is NOT a cloning vector?
(A) Phage
(B) Plasmid
(C) Agrose
(D) Cosmid

78. The expression of recombinant proteins in plant systems can be achieved using vectors derived from:
(A) Escherichia coli.
(B) Saccharomyces cerevisiae.
(C) Baculovirus.
(D) Agrobacterium tumefaciens.

79. The generation of a genomic library involves:
(A) partially digesting total genomic DNA and cloning fragments into vectors.
(B) isolating total cellular mRNA and converting it into stable cDNA copies.
(C) amplifying specifically targeted gene sequences using PCR and primers.
(D) determining the full nucleotide sequence of the entire genome directly.

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80. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In RFLP analysis, different individuals may show different patterns of DNA fragments.
Reason (R): The presence or absence of restriction sites can vary between individuals, leading to fragments of different lengths.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

81. The application of biotechnology in horticulture includes:
(A) the development of bioreactors for waste treatment.
(B) the production of micropropagation-based disease-free planting material.
(C) the manufacturing of vaccines and hormones.
(D) the use of DNA fingerprinting in criminal forensics.

82. Ethical concerns in biotechnology often revolve around issues such as:
(A) the patenting of life forms and genetic determinism.
(B) the cost of laboratory equipment.
(C) the choice of buffer systems for electrophoresis.
(D) the publication of research in high-impact journals.

83. Which technique is a cornerstone of genetic engineering of plants, allowing for the introduction of foreign genes?
(A) DNA fingerprinting
(B) RFLP analysis
(C) Recombinant DNA technology
(D) Southern blotting

84. The three main steps in a single PCR cycle are:
(A) Ligation, Transformation, Selection.
(B) Transcription, Translation, Protein folding.
(C) Denaturation, Hybridization, Ligation.
(D) Denaturation, Annealing, Extension.

85. Which component of an electron microscope is analogous to the glass lens of a light microscope?
(A) The electron gun
(B) The vacuum pump
(C) The electromagnetic lens
(D) The fluorescent screen

86. Staining tissue sections with heavy metals like lead and uranium is done to:
(A) preserve the tissue from degradation.
(B) increase the contrast of structures in electron microscopy.
(C) make the tissue fluorescent for light microscopy.
(D) measure the pH of the cellular compartments.

87. Which of the following is a key difference between a genomic DNA library and a cDNA library?
(A) A genomic library is made from RNA, while a cDNA library is made from DNA.
(B) A genomic library only contains protein-coding genes.
(C) A cDNA library is representative of all tissues in an organism.
(D) A genomic library contains introns, while a cDNA library does not.

88. The main purpose of adding SDS (sodium dodecyl sulfate) to protein samples before electrophoresis is to:
(A) impart a uniform negative charge and denature the proteins.
(B) impart a uniform positive charge to all proteins.
(C) preserve the native structure and charge of the proteins.
(D) stain the proteins so they can be visualized.

89. A researcher is studying the binding kinetics between a drug and its target protein in real-time without labeling either molecule. Which technique is most suitable?
(A) ELISA
(B) Western Blotting
(C) Surface Plasmon Resonance (SPR)
(D) Flow Cytometry

90. In the analysis of biomolecules, what does 'differentiations' in the context of NMR refer to?

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(A) Distinguishing between different chemical environments of nuclei.
(B) Separating different types of biomolecules before analysis.
(C) The mathematical process of differentiating signals to enhance resolution.
(D) The differentiation of cells before NMR analysis.

91. The technique of identifying molecules in living cells through antibody-based detection is broadly termed as:
(A) In situ hybridization.
(B) Flow cytometry.
(C) Southern blotting.
(D) Immunocytochemistry or Immunofluorescence.

92. What is the role of the DNA polymerase enzyme in a PCR reaction?
(A) To unwind the double-stranded DNA template.
(B) To synthesize new DNA strands using the template and primers.
(C) To join the DNA fragments together.
(D) To degrade RNA from the sample.

93. A patent, as a form of intellectual property rights, grants the inventor:
(A) permanent ownership of a scientific fact.
(B) a monopoly on publishing research in a specific area.
(C) an exclusive right to make, use, and sell the invention for a limited time.
(D) a certificate of scientific achievement from the government.

94. The use of genetically engineered bacteria to break down oil spills is an example of:
(A) agricultural biotechnology.
(B) healthcare biotechnology.
(C) phytoremediation.
(D) bioremediation.

95. Match List-I with List-II regarding molecular markers and their features.
List I: (Molecular Marker)
P. RFLP
Q. RAPD
R. AFLP
S. Microsatellite
List II: (Key Feature)
1. Amplification using short, random primers
2. Selective amplification of restriction fragments
3. Tandem repeats of a few nucleotides (e.g., CACACA...)
4. Variation in restriction enzyme cutting sites
Choose the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-3, S-1

96. Which type of microscopy creates an image where the specimen appears bright against a dark background?
(A) Bright field microscopy
(B) Dark field microscopy
(C) Phase contrast microscopy
(D) Nomarski microscopy

97. Given below are two statements:
Statement I: Osmium tetroxide acts as both a fixative and a stain for electron microscopy.
Statement II: Osmium binds to lipids, making membranes electron-dense and thus visible.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

98. The resolving power of a microscope is best defined as the ability to:
(A) distinguish between two closely spaced points as separate entities.
(B) make a microscopic object appear significantly larger than reality.
(C) produce a high-contrast image using specific staining techniques.
(D) observe living specimens without the need for chemical staining.

99. In chromatography, the component that interacts most strongly with the stationary phase will:
(A) elute from the column first.
(B) not enter the column.
(C) elute from the column last.
(D) move at the same speed as the mobile phase.

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(B) phase contrast requires staining, while dark-field does not at all.
(C) dark-field has higher resolution than phase contrast for all cells.
(D) phase contrast uses phase shifts, whereas dark-field uses light scatter.

142. A major purpose of using a laminar air flow hood is to:
(A) maintain anaerobic conditions for bacterial culture.
(B) provide a sterile environment for cell culture work.
(C) protect the user from hazardous chemicals.
(D) incubate samples at a constant temperature.

143. Which technique is based on the diffraction of a monochromatic X-ray beam by a crystallized molecule?
(A) NMR Spectroscopy
(B) Mass Spectrometry
(C) X-ray Crystallography
(D) Circular Dichroism

144. In a sandwich ELISA, what is immobilized on the surface of the microtiter plate?
(A) The antigen
(B) The secondary antibody
(C) The enzyme substrate
(D) The primary antibody

145. "Knockout" mice are invaluable in biomedical research because they allow scientists to:
(A) study the function of a gene by observing the effects of its absence.
(B) increase the production of a specific protein.
(C) trace the lineage of cells during development.
(D) create animal models for infectious diseases.

146. A BAC vector is based on the F-plasmid of which organism?
(A) Saccharomyces cerevisiae
(B) Escherichia coli
(C) Agrobacterium tumefaciens
(D) Bacteriophage lambda

147. What is the role of DNA ligase in molecular cloning?
(A) It cuts DNA at specific recognition sites.
(B) It forms phosphodiester bonds to join DNA fragments.
(C) It synthesizes a new DNA strand.
(D) It unwinds the DNA double helix.

148. The application of biotechnology in immunology includes all of the following EXCEPT:
(A) development of herbicide-resistant crops.
(B) production of monoclonal antibodies.
(C) development of vaccines.
(D) creation of diagnostic kits like ELISA.

149. The "bio" in "biotechnology" refers to the use of:
(A) biodegradable materials.
(B) computer simulations of biological processes.
(C) living organisms or their components to make products.
(D) biological safety cabinets.

150. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): 2D gel electrophoresis provides better resolution of proteins than 1D gel electrophoresis.
Reason (R): It separates proteins based on two independent properties, isoelectric point and molecular mass.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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151. Which of these is a limitation of light microscopy compared to electron microscopy?
(A) Inability to observe living cells.
(B) Requirement for all samples to be coated in gold.
(C) Inability to use colored stains.
(D) Lower magnification and resolution.

152. In isoelectric focusing, a protein will migrate through the pH gradient until it reaches a point where:
(A) its molecular weight is lowest.
(B) its net charge is zero.
(C) it is fully denatured.
(D) it binds to the gel matrix.

111. What is a key advantage of freeze-etching over standard chemical fixation for EM?
(A) It is much faster and cheaper.
(B) It provides better surface topography images than SEM.
(C) It does not require the use of a vacuum.
(D) It avoids potential artifacts caused by chemical reactions.

112. The analysis of protein-protein interactions within a cell can be effectively studied using:
(A) standard Southern Blotting techniques for DNA.
(B) Yeast Two-Hybrid system or Co-Immunoprecipitation.
(C) high-resolution DNA fingerprinting analysis.
(D) RFLP analysis of targeted genomic regions.

113. A microarray, or 'gene chip', contains thousands of:
(A) microscopic wells designed for high-throughput cell culture.
(B) specialized antibodies spotted in an ordered array on glass.
(C) immobilized single-stranded DNA probes in an ordered array.
(D) miniaturized electrophoresis gels for separating proteins.

114. The isolation and analysis of carbohydrate molecules often involves techniques like:
(A) standard SDS-PAGE and subsequent Western blotting.
(B) targeted PCR and high-fidelity DNA sequencing.
(C) multi-color flow cytometry and FISH analysis.
(D) HPLC and high-resolution Mass Spectrometry.

115. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): YACs and BACs are used for cloning very large DNA fragments.
Reason (R): Standard plasmids and phage vectors have a limited insert size capacity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

116. 'Golden Rice' is a well-known example of using genetic engineering in agriculture to:
(A) increase the yield of rice crops.
(B) make rice plants resistant to pests.
(C) make rice plants tolerant to drought.
(D) enhance the nutritional value of rice (pro-vitamin A).

117. In the context of intellectual property rights, what does the term 'prior art' refer to?
(A) all public knowledge and disclosures existing before a patent filing.
(B) an invention that has already been granted a legal patent status.
(C) the specific aesthetic or artistic design of a laboratory instrument.
(D) the historical development and evolution of a specific scientific theory.

118. The Taq polymerase used in PCR is notable for its:
(A) ability to synthesize RNA from a DNA template.
(B) high fidelity and lack of errors.
(C) thermostability (resistance to high temperatures).
(D) origin from a human cell line.

119. A defining characteristic of a bacterial expression vector, as opposed to a simple cloning vector, is the presence of:
(A) a functional origin of replication for the host.
(B) a promoter recognized by the host's RNA polymerase.
(C) a selectable marker for identifying transformed cells.
(D) a multiple cloning site for inserting foreign DNA.

120. Which technique would you use to compare the entire set of proteins expressed by a cell under two different conditions?
(A) standard Southern Blotting analysis.
(B) RFLP genomic analysis.
(C) FISH chromosomal analysis.

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(D) 2D-Gel Electrophoresis and Mass Spectrometry.

121. The first step in isolating genomic DNA from a plant cell that is not required for animal cells is:
(A) breaking down the cellulose cell wall via enzymatic or mechanical means.
(B) lysing the cell membrane with a specialized detergent-based solution.
(C) degrading cellular proteins with a broad-spectrum protease enzyme.
(D) degrading RNA from the sample using a purified RNase treatment.

122. In in vitro mutagenesis, a "deletion technique" specifically aims to:
(A) substitute one base for another.
(B) insert one or more extra bases into a DNA sequence.
(C) remove one or more nucleotide bases from a DNA sequence.
(D) create random point mutations across the gene.

123. Which of the following best describes the principle of 'in situ localization'?
(A) purifying a specific molecule from a complex cell lysate.
(B) analyzing the movement of a target molecule in real-time.
(C) separating molecules based on their individual size and charge.
(D) detecting a molecule in its original position within the cell.

124. The difference between GISH and FISH is that GISH uses:
(A) a protein probe, whereas the FISH technique utilizes a DNA probe.
(B) total genomic DNA from one species as a probe to identify origins.
(C) a specific gene probe, whereas FISH uses a whole chromosome probe.
(D) fluorescent antibodies, whereas FISH uses labeled DNA sequences.

125. Match List-I with List-II regarding techniques and their specific applications.
List I: (Technique)
P. Flow Cytometry
Q. Surface Plasmon Resonance
R. Circular Dichroism
S. X-ray Crystallography
List II: (Specific Application)
1. Determining protein secondary structure
2. Determining high-resolution 3D atomic structure
3. Sorting cells based on surface markers
4. Analyzing real-time molecular binding kinetics
Choose the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

126. What physical property of biomolecules is primarily exploited in centrifugation?
(A) Net electrical charge
(B) Solubility in water
(C) Absorption of visible light
(D) Mass, density, and shape

127. Image processing methods in microscopy can be used for all of the following EXCEPT:
(A) initial generation of the image from the specimen.
(B) noise reduction and contrast enhancement.
(C) 3D reconstruction from a series of 2D images.
(D) automated counting of cells or particles.

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128. In UV-Visible spectroscopy, a wavelength scan is performed to find the λ_max (lambda max), which is the wavelength of:
(A) minimum absorbance.
(B) maximum fluorescence.
(C) maximum absorbance.
(D) zero transmittance.

129. What is the fundamental requirement for a molecule to be studied by Electron Spin Resonance (ESR) spectroscopy?
(A) It must be a protein.
(B) It must contain at least one unpaired electron.
(C) It must be fluorescent.
(D) It must be in a crystalline state.

130. Consider the following statements about blotting techniques:
I. Southern blotting detects specific DNA

sequences.
II. Western blotting uses antibodies to detect specific proteins.
III. Northern blotting detects specific RNA sequences.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

131. The purpose of a poly-A tail on eukaryotic mRNA is exploited in the purification of mRNA using:
(A) ion-exchange chromatography.
(B) gel filtration chromatography.
(C) oligo(dT) affinity chromatography.
(D) sucrose density gradient centrifugation.

132. The process where a bacterial cell takes up foreign plasmid DNA from the environment is called:
(A) conjugation.
(B) transduction.
(C) transcription.
(D) transformation.

133. Monoclonal antibodies are homogenous because they are:
(A) produced by a single B-cell clone (hybridoma).
(B) produced by different B-cell clones.
(C) a mix of antibodies that recognize different antigens.
(D) purified from the serum of an immunized animal.

134. Side scatter (SSC) in flow cytometry provides information about a cell's:
(A) size.
(B) internal complexity or granularity.
(C) speed through the laser.
(D) fluorescence intensity.

135. A "knock-in" mouse is a genetically engineered mouse where:
(A) a gene is completely removed.
(B) a gene is replaced by another gene or a modified version.
(C) a gene's expression is temporarily silenced.
(D) an extra copy of a gene is added randomly.

136. The major advantage of using BAC and YAC vectors is their:
(A) large carrying capacity for foreign DNA.
(B) high copy number in host cells.
(C) ability to be expressed in both bacteria and yeast.
(D) simple purification protocol.

137. Which of the following is an example of an application of biotechnology in forestry?
(A) industrial production of recombinant human growth hormones.
(B) microbial bioremediation of major marine oil spill events.
(C) developing GM trees with faster growth or disease resistance.
(D) industrial manufacturing of commercial cheese and yogurt.

138. The variable number tandem repeats (VNTRs) used in DNA fingerprinting are a type of:
(A) mitochondrial DNA.
(B) ribosomal RNA gene.
(C) single nucleotide polymorphism.
(D) minisatellite DNA.

139. In a pH meter, the potential difference is measured between a reference electrode and a:
(A) platinum electrode.
(B) zinc electrode.
(C) glass electrode sensitive to H+ ions.
(D) copper electrode.

140. The following steps are involved in Western blotting:
I. Incubation with a primary antibody.
II. Protein transfer from gel to membrane.
III. Detection using a labeled secondary antibody.
IV. Separation of proteins by SDS-PAGE.
Which of the following is the correct chronological sequence?
(A) IV, II, I, III
(B) I, II, III, IV
(C) IV, I, II, III
(D) II, IV, I, III

141. The main difference between phase contrast and dark-field microscopy is that:
(A) dark-field visualizes the specimen on a bright background profile.

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100. Consider the following statements about PCR:
I. It requires a thermostable DNA polymerase.
II. The temperature is raised to ~95°C to denature the DNA.
III. It can amplify DNA but not RNA directly.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

101. Which of the following describes the application of advanced NMR techniques such as 2D-NMR and NOESY?
(A) They are used to study cell differentiation processes.
(B) They help differentiate between and identify connected protons.
(C) They help differentiate NMR from ESR spectroscopy.
(D) They involve the mathematical differentiation of the Free Induction Decay (FID) signal.

102. What is a primary limitation of using RAPD markers in genetic analysis?
(A) They often suffer from poor reproducibility.
(B) The protocol is very expensive and time-consuming.
(C) They require a large amount of DNA.
(D) They can only be used on plant genomes.

103. Which technique would be most appropriate for determining if a specific transcription factor protein is bound to a particular promoter sequence in vivo?
(A) Western Blotting
(B) Southern Blotting
(C) Chromatin Immunoprecipitation (ChIP)
(D) RFLP

104. The process of transferring DNA from an electrophoresis gel to a solid membrane is a key step in:
(A) Western blotting.
(B) isoelectric focusing.
(C) flow cytometry.
(D) Southern blotting.

105. A cosmid vector is a hybrid of a plasmid and the 'cos' sites of which other vector type?
(A) YAC
(B) BAC
(C) Bacteriophage lambda
(D) Ti plasmid

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106. In the context of molecular cloning, what is the role of a 'selectable marker' on a plasmid?
(A) It provides a site for the insertion of foreign DNA.
(B) It allows for the identification of cells that have successfully taken up the plasmid.
(C) It facilitates the replication of the plasmid in the host cell.
(D) It initiates the expression of the cloned gene.

107. The production of human insulin in bacteria is a major achievement of biotechnology in the field of:
(A) agriculture.
(B) environmental science.
(C) food industry.
(D) healthcare.

108. Which of the following is NOT a principle of biotechnology ethics?
(A) Profitability (ensuring financial gain)
(B) Non-maleficence (do no harm)
(C) Justice (fair distribution of benefits and burdens)
(D) Beneficence (doing good)

109. Which separation method is based on the movement of particles through a liquid medium under the force of gravity or centrifugal force?
(A) Electrophoresis
(B) Chromatography
(C) Sedimentation (Centrifugation)
(D) Dialysis

110. In fluorescence microscopy, a dichroic mirror is used to:
(A) separate the excitation light from the emitted fluorescence signal.
(B) magnify the primary image formed by the objective lens system.
(C) focus the excitation light beam directly onto the target specimen.
(D) detect the emitted light using a high-sensitivity sensor camera.

153. The 'Southern' in Southern blotting refers to:
(A) the geographical direction the DNA migrates.
(B) the use of a positively charged membrane.
(C) the name of its inventor, Edwin Southern.
(D) the specific type of buffer used.

154. To generate a cDNA library, which enzyme is essential?
(A) DNA Polymerase I
(B) Restriction Endonuclease
(C) DNA Ligase
(D) Reverse Transcriptase

155. Which vector would be the best choice for generating a genomic library of a human, which has a very large genome?
(A) A Yeast Artificial Chromosome (YAC)
(B) A bacteriophage lambda vector
(C) A standard plasmid vector
(D) A T-vector for PCR products

156. Genetic engineering of plants often involves the use of the Ti plasmid from:
(A) Escherichia coli.
(B) Agrobacterium tumefaciens.
(C) Bacillus thuringiensis.
(D) Saccharomyces cerevisiae.

157. The primary reason for patenting a biotechnological invention is to:
(A) prevent others from using the scientific knowledge.
(B) gain commercial advantage and recoup research and development costs.
(C) obtain government funding for research.
(D) ensure the ethical use of the technology.

158. The DNA polymerase used in PCR must be thermostable because:
(A) the denaturation step, at ~95°C, would destroy a normal polymerase.
(B) the annealing step occurs at a high temperature.
(C) the extension step requires a very high temperature for accuracy.
(D) the primers only bind at high temperatures.

159. What is the fundamental difference between analysis of DNA and analysis of RNA by gel electrophoresis?
(A) DNA is stained with ethidium bromide, while RNA is not.
(B) DNA moves towards the positive electrode, while RNA moves to the negative.
(C) RNA is single-stranded and requires denaturing conditions to prevent secondary structures.
(D) RNA must be cut by restriction enzymes before running on a gel.

160. Match List-I with List-II regarding molecular techniques and their core principles.
List I: (Technique)
P. PCR
Q. RFLP
R. FISH
S. ELISA
List II: (Core Principle)
1. Hybridization of a fluorescent probe to a chromosome
2. Enzymatic detection of an antigen-antibody complex
3. In vitro amplification of a DNA sequence
4. Digestion of DNA with restriction enzymes
Choose the correct option:
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

161. A researcher observes that a protein sample shows a strong absorbance peak at 280 nm in a UV spectrophotometer. This is primarily due to the presence of:
(A) aromatic amino acids like tryptophan and tyrosine.
(B) peptide bonds.
(C) proline and glycine residues.
(D) negatively charged amino acids like aspartate and glutamate.

162. Fluorescence occurs when a molecule:
(A) absorbs light of a specific wavelength and emits light at the same wavelength.
(B) scatters light without changing its wavelength.
(C) absorbs light and converts it into heat.
(D) absorbs light and emits light of a longer wavelength.

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163. The role of a microtome is most closely associated with which other technique?
(A) Flow cytometry
(B) Light and electron microscopy
(C) PCR
(D) Chromatography

164. All of the following are commonly used for protein purification EXCEPT:
(A) Ion-exchange chromatography.
(B) Gel filtration chromatography.
(C) RFLP analysis.
(D) Affinity chromatography.

165. Consider the following statements about gene knockout technology:
I. It is a form of reverse genetics, where a gene is disrupted to study its function.
II. It can be performed in both bacterial and eukaryotic organisms.
III. It often relies on homologous recombination to replace the target gene.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

166. Which type of mass spectrometry is often coupled with gas chromatography (GC-MS) or liquid chromatography (LC-MS) for complex mixture analysis?
(A) All common types of mass spectrometry are coupled in this specific way.
(B) Techniques like Electrospray Ionization (ESI) and similar interfaces.
(C) Standard MALDI-TOF analysis used for various large biomolecules.
(D) Spark Ionization Mass Spectrometry used for elemental sample analysis.

167. Immunodetection of molecules in living cells, as opposed to fixed cells, requires specialized techniques like:
(A) standard immunofluorescence with membrane permeabilization.
(B) western blotting of the cell lysate.
(C) electron microscopy.
(D) expression of antibody fragments (intrabodies) within the cell.

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168. The primary advantage of AFLP is that it:
(A) samples a larger genomic portion and is more reproducible than RAPD.
(B) is significantly cheaper and faster than any other marker technique.
(C) does not require the use of any radioactivity or fluorescence labels.
(D) requires no prior knowledge of the target organism's genome sequence.

169. What is the purpose of the 'phage' component in a 'phage vector' for molecular cloning?
(A) To provide antibiotic resistance.
(B) To allow for the cloning of extremely large DNA fragments.
(C) To facilitate the delivery of the cloned DNA into bacterial host cells.
(D) To ensure the expression of the cloned gene.

170. 'Bt corn' is a genetically engineered plant that expresses a protein from the bacterium Bacillus thuringiensis. This application of biotechnology provides the plant with:
(A) resistance to certain insect pests.
(B) resistance to herbicides.
(C) tolerance to drought conditions.
(D) enhanced nutritional content.

171. Which statement about phase contrast microscopy is INCORRECT?
(A) It is ideal for observing unstained, living specimens.
(B) It creates contrast by exploiting differences in refractive index.
(C) It uses a phase plate to alter the phase of light.
(D) It requires staining the specimen with heavy metals.

172. The freeze-fracture technique provides a unique view of the:
(A) outer surface of the cell wall.
(B) internal face of cellular membranes.
(C) chromosomal arrangement in the nucleus.
(D) ribosomal structure on the endoplasmic reticulum.

173. What is measured by a colorimeter?
(A) the specific pH value of a given biological solution.
(B) the electrical conductivity of a concentrated

ionic sample.
(C) the absorbance or transmittance of light by a colored solution.
(D) the dynamic rate of a specific catalyzed chemical reaction.

174. Which of the following is NOT a biophysical method for analyzing biomolecules?
(A) Nuclear Magnetic Resonance (NMR)
(B) X-ray Crystallography
(C) Surface Plasmon Resonance (SPR)
(D) Light microscopy

175. The signal in Circular Dichroism (CD) spectroscopy arises from the differential absorption of:
(A) left and right circularly polarized light.
(B) UV and visible light.
(C) high and low frequency radio waves.
(D) horizontally and vertically polarized light.

176. Which of the following best describes immunoprecipitation?
(A) A method used to precipitate all proteins from a complex cell solution.
(B) A technique using an antibody to specifically pull down its antigen.
(C) A process of precipitating antibodies using high concentrations of salt.
(D) A specialized type of chromatography used for separating immunoglobulins.

177. A key component required for in vitro mutagenesis to create a specific point mutation is:
(A) a random oligonucleotide primer used during PCR amplification.
(B) a synthetic primer containing the specifically desired mutation.
(C) a reverse transcriptase enzyme used for creating cDNA templates.
(D) a wild-type DNA template containing the original gene sequence.

178. What does RFLP stand for?
(A) Restriction Fragment Length Polymorphism
(B) Random Fragment Length Polymorphism
(C) Repetitive Fragment Locus Polymorphism
(D) RNA Fragment Length Polymorphism

179. The purpose of using ethidium bromide or SYBR Green in gel electrophoresis of DNA is to:
(A) help the DNA migrate through the gel.
(B) maintain a constant pH in the buffer.
(C) visualize the DNA under UV light.
(D) denature the DNA into single strands.

180. The function of a YAC vector depends on components necessary for chromosome stability in its host, which is:
(A) Escherichia coli.
(B) a plant cell.
(C) an insect cell.
(D) Saccharomyces cerevisiae (yeast).

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181. A 'genomic library' is a collection of:
(A) all the proteins expressed in a single biological cell type.
(B) all the messenger RNA molecules present in a specific tissue.
(C) recombinant vectors that contain the entire genome of an organism.
(D) all the known gene sequences for a species in a digital database.

182. Which of the following represents an ethical issue specific to genetic engineering?
(A) the significant financial cost of building a modern research laboratory.
(B) the potential for unintended ecological consequences of releasing GMOs.
(C) the personal choice of which scientific journal to publish findings in.
(D) the standard disposal procedures for common laboratory chemical waste.

183. The enzyme that joins the Okazaki fragments on the lagging strand during DNA replication is the same enzyme used in molecular cloning to join a DNA insert to a vector. This enzyme is:
(A) DNA polymerase.
(B) Helicase.
(C) Primase.
(D) DNA ligase.

184. The 'fingerprint' in DNA fingerprinting refers to:
(A) the unique pattern of gel bands representing an individual's DNA.
(B) the specific nucleotide sequence of a common gene like hemoglobin.

product of that specific gene.
(B) to tag the targeted gene with a detectable fluorescent protein marker.
(C) to create a comprehensive genomic library for future genetic research.
(D) to study gene function by observing results of the phenotypic absence.

268. The difference between a genomic DNA library and a cDNA library is that the cDNA library:
(A) is made from mRNA and represents only the expressed genes.
(B) represents the entire genome, including non-coding regions.
(C) is much larger and more complex.
(D) can only be made from bacterial cells.

269. The 'Polymerase Chain Reaction' is used in molecular biology to:
(A) sequence DNA.
(B) separate proteins.
(C) amplify specific DNA sequences.
(D) create mutations in DNA.

270. Consider the following statements about immunotechniques:
I. ELISA uses an enzyme-linked antibody for detection.
II. Flow cytometry can sort cells based on their properties.
III. Western blotting is used to detect specific DNA sequences.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

271. In recombinant DNA technology, the process of introducing a plasmid into a bacterial cell is called:
(A) Transcription
(B) Transformation
(C) Translation
(D) Ligation

272. Intellectual Property Rights (IPR) are important in biotechnology because they:
(A) ensure that all research findings are made freely available to the public.
(B) regulate the safety and efficacy of modern biotechnological products.
(C) set universal ethical guidelines for all international biological research.
(D) provide incentives for innovation by allowing profit from various works.

273. The separation of serum proteins by electrophoresis is an example of what basic laboratory technique?
(A) Electrophoresis
(B) Chromatography
(C) Centrifugation
(D) Spectrophotometry

274. In a TEM, the electrons that form the image are those that:
(A) are scattered from the surface of the specimen.
(B) are transmitted through the specimen.
(C) are emitted by a fluorescent screen.
(D) are reflected by the condenser lens.

275. Circular Dichroism (CD) is an excellent method for monitoring changes in a protein's:
(A) primary structure (amino acid sequence).
(B) secondary structure (alpha-helix, beta-sheet).
(C) molecular weight.
(D) isoelectric point.

276. In an immunoprecipitation experiment, what is used to capture the antibody-antigen complex from the solution?
(A) Protein A or Protein G beads.
(B) A nitrocellulose membrane.
(C) A second antibody that binds the first.
(D) A pH gradient.

277. The key innovation of the AFLP technique over RFLP is the addition of:
(A) fluorescent labeling.
(B) two-dimensional gel electrophoresis.
(C) PCR amplification.
(D) isoelectric focusing.

278. Which of the following vectors can carry the largest DNA insert?
(A) Plasmid
(B) Cosmid
(C) Bacteriophage λ
(D) YAC (Yeast Artificial Chromosome)

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195. Match List-I with List-II regarding cloning vectors and their typical insert size capacities.
List I: (Cloning Vector)
P. Plasmid
Q. Bacteriophage λ
R. Cosmid
S. BAC
List II: (Typical Insert Size Capacity)
1. 35-45 kb
2. up to 300 kb
3. 5-25 kb
4. < 15 kb
Choose the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-4, R-1, S-3

196. The purpose of fluorescence in fluorescence microscopy is to:
(A) provide structural information at the atomic level.
(B) achieve high-magnification imaging of surfaces.
(C) measure the mass of the specimen.
(D) generate contrast to visualize specific molecules or structures.

197. Given below are two statements:
Statement I: UV spectroscopy can be used to estimate protein concentration by measuring absorbance at 280 nm.
Statement II: Visible spectroscopy is used to measure the concentration of colored compounds, such as in the Bradford protein assay.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

198. The main advantage of using a phase contrast microscope over a simple bright-field microscope is the ability to:
(A) view specimens at a much higher magnification.
(B) visualize unstained and living cells with high contrast.
(C) create a three-dimensional image of the specimen's surface.
(D) identify specific molecules using fluorescent dyes.

199. What is the purpose of adding a blocking agent (like non-fat milk or BSA) to a membrane in a Western blot?
(A) To transfer the proteins from the electrophoresis gel to the membrane.
(B) To denature the proteins currently immobilized on the membrane surface.
(C) To prevent antibodies from binding non-specifically to the membrane.
(D) To activate the reporter enzyme conjugated to the secondary antibody.

200. Consider the following statements regarding nucleic acid analysis:
I. Southern blotting is used for DNA analysis.
II. Northern blotting is used for protein analysis.
III. Western blotting is used for RNA analysis.
Which of the above statement(s) is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) I, II and III

201. The technique of microarray analysis allows for:
(A) the simultaneous measurement of the expression levels of thousands of genes.
(B) the sequencing of a single gene of interest.
(C) the separation of proteins based on their isoelectric point.
(D) the targeted deletion of a gene from the genome.

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202. The first step in creating a cDNA library from a eukaryotic organism is:
(A) isolating total genomic DNA.
(B) digesting DNA with restriction enzymes.
(C) performing a PCR reaction.
(D) isolating messenger RNA (mRNA).

203. Which vector is commonly used for creating genetically modified plants?
(A) YAC vector
(B) Ti plasmid-based vector
(C) BAC vector
(D) Lambda phage vector

(D) create specific, predetermined changes in a given DNA sequence.

246. What type of information does a 2D-gel electrophoresis provide?
(A) the specific DNA nucleotide sequence of a target gene.
(B) relative abundance, pI, and molecular weight of many proteins.
(C) the physical location of a specific gene on a chromosome.
(D) the binding affinity and strength of a protein to its ligand.

247. A cDNA molecule is a:
(A) DNA molecule found in the cytoplasm.
(B) circular DNA molecule.
(C) DNA copy of an RNA molecule.
(D) DNA molecule that contains introns.

248. The development of which technologies spurred the "Golden Age" of biotechnology?
(A) The light microscope.
(B) Pasteurization.
(C) Fermentation techniques.
(D) Recombinant DNA technology and PCR.

249. The development of crops resistant to the herbicide glyphosate is an example of:
(A) genetic engineering of plants.
(B) traditional breeding.
(C) environmental biotechnology.
(D) food processing technology.

250. Which of the following is NOT required to perform a Western blot?
(A) A specific primary antibody.
(B) A DNA probe.
(C) An SDS-PAGE gel.
(D) A labeled secondary antibody.

251. A 'microtome' is an instrument used for:
(A) culturing microorganisms.
(B) cutting extremely thin sections of biological material.
(C) measuring small volumes of liquid.
(D) viewing microscopic organisms.

252. The analysis of biomolecules using Fluorescence spectroscopy provides information on:
(A) changes in the local environment of a fluorophore.
(B) the molecular weight of the biomolecule.
(C) the atomic structure of the biomolecule.
(D) the isoelectric point of a protein.

253. The purpose of the 'blotting' or transfer step in Southern and Western blotting is to:
(A) visualize the target molecules directly within the electrophoresis gel.
(B) label target molecules with a radioactive tag or an enzymatic reporter.
(C) move separated molecules from a fragile gel to a solid support membrane.
(D) break down separated molecules into significantly smaller fragments.

254. The term for a genetically engineered organism that carries a gene from a different species is:
(A) hybrid.
(B) clone.
(C) mutant.
(D) transgenic.

255. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In size-exclusion chromatography, large molecules elute from the column faster than small molecules.
Reason (R): Large molecules are excluded from the pores of the stationary phase beads and thus have a shorter path to travel through the column.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

256. Which of the following is an example of an application of biotechnology in the healthcare industry?
(A) The production of cheese using rennet.
(B) The production of recombinant human insulin.
(C) The development of insect-resistant cotton.
(D) The use of bacteria to clean up oil spills.

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SEM shows internal ultrastructure.
(B) TEM requires a thin section of the specimen, while SEM can view the surface of bulk samples.
(C) SEM has a much higher resolution than TEM.
(D) TEM uses light waves, while SEM uses electrons.

215. What is the primary information obtained from an NMR spectrum of a protein?
(A) the exact primary amino acid sequence of a purified protein.
(B) the total molecular weight and mass of the target protein.
(C) the protein's relative stability under high heat conditions.
(D) information about the chemical environment and atomic connectivity.

216. In an ELISA test, the final step involves adding a substrate which is converted by the enzyme into a:
(A) colored product.
(B) radioactive signal.
(C) fluorescent signal.
(D) precipitating agent.

217. A gene knockout is a powerful tool in genetics primarily because it helps to:
(A) increase the quantitative amount of protein produced by a single gene.
(B) create multiple high-fidelity copies of a specific gene for sequencing.
(C) determine the function of the gene by observing phenotypic absence.
(D) introduce a completely foreign or synthetic gene into a host organism.

218. The main advantage of a two-dimensional gel electrophoresis over a one-dimensional gel is:
(A) it is faster to run.
(B) it requires less protein sample.
(C) it can be used to separate DNA as well as proteins.
(D) it provides a much greater separation and resolution of proteins.

219. The isolation of specific nucleic acid sequences can be achieved by using a labeled:
(A) probe.
(B) protein.
(C) lipid.
(D) carbohydrate.

220. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): A cDNA library is smaller and less complex than a genomic library from the same eukaryotic organism.
Reason (R): A cDNA library only contains sequences corresponding to the exons of transcribed genes, while a genomic library contains all DNA, including introns and intergenic regions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

221. The use of Agrobacterium tumefaciens to create transgenic plants is an example of biotechnology applied to:
(A) healthcare.
(B) environmental cleanup.
(C) food processing.
(D) agriculture and horticulture.

222. Which of the following is a key characteristic of the RAPD technique?
(A) It requires knowledge of the target DNA sequence.
(B) It uses a single, short, arbitrary primer.
(C) It involves restriction digestion of the DNA.
(D) It is known for its high reproducibility.

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223. What is a 'cosmid'?
(A) small circular plasmid used specifically for cloning short PCR products.
(B) specialized artificial chromosome designed for use within yeast cells.
(C) a hybrid vector containing plasmid sequences and phage 'cos' sites.
(D) a large vector derived from the Ti plasmid found in Agrobacterium species.

(C) the physical impression of a fingertip used in forensic identification.
(D) the total quantitative amount of DNA present in an individual's cells.

185. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): It is not possible to use restriction enzymes to digest RNA.
Reason (R): Restriction enzymes recognize and cleave specific sequences in double-stranded DNA, and RNA is typically single-stranded.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

186. The resolution of an electron microscope is limited by the:
(A) quality of the glass lenses.
(B) wavelength of the electrons.
(C) intensity of the light source.
(D) size of the specimen.

187. The purpose of an isoelectric focusing gel is to:
(A) create a stable pH gradient for protein separation by charge.
(B) separate proteins by size only.
(C) separate DNA fragments based on their length.
(D) transfer proteins to a membrane for blotting.

188. In flow cytometry, cells are passed one by one through:
(A) a strong magnetic field.
(B) an electrophoresis gel.
(C) a focused laser beam.
(D) a chromatography column.

189. A key difference between RFLP and RAPD is that:
(A) RFLP relies on PCR, while the RAPD technique does not use it.
(B) RFLP is used for protein analysis, while RAPD is for DNA analysis.
(C) RAPD is generally more reproducible than the standard RFLP method.
(D) RAPD uses PCR with random primers, whereas RFLP uses restriction.

190. What is the purpose of 'expression' in the context of 'expression of recombinant proteins'?
(A) To isolate and chemically purify the protein from the host cells.
(B) To clone the target gene into a specialized circular DNA vector.
(C) To make host cells transcribe and translate a gene into a protein.
(D) To sequence the specific DNA nucleotides of the cloned target gene.

191. Which of the following vectors is a plasmid?
(A) The DNA of a virus that infects bacteria.
(B) A small, circular, extrachromosomal DNA molecule found in bacteria.
(C) An artificial chromosome that can be maintained in yeast.
(D) A linear DNA molecule used for cloning.

192. One of the main goals of biotechnology in the food industry is to:
(A) develop new and sustainable packaging materials for food products.
(B) create new marketing and branding strategies for food industries.
(C) study the nutritional needs and deficiencies of a local population.
(D) use biological agents to improve food quality, safety, and production.

193. The primary principle behind separating molecules by gel filtration (size-exclusion) chromatography is that:
(A) smaller molecules enter the pores of the beads and elute last.
(B) larger molecules are retained by the beads and elute last.
(C) charged molecules bind to the beads.
(D) molecules bind to specific ligands on the beads.

194. Which of these is NOT a component of a typical PCR reaction mix?
(A) DNA template
(B) Primers
(C) RNA polymerase
(D) dNTPs

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235. Which of the following is NOT a cloning vector?
(A) Plasmid
(B) ELISA
(C) Cosmid
(D) YAC

236. The expression of recombinant proteins in animal cell culture systems is often preferred over bacterial systems when:
(A) the protein requires specific post-translational modifications like glycosylation.
(B) large quantities of protein are needed quickly and cheaply.
(C) the protein is very small and simple in structure.
(D) the gene to be cloned has no introns.

237. One of the earliest applications of biotechnology in healthcare was the:
(A) development of modern MRI scanners for clinical diagnostics.
(B) invention of the common stethoscope for medical examinations.
(C) production of penicillin antibiotics from various microorganisms.
(D) use of various synthetic drugs in the treatment of diseases.

238. What is the role of primers in a PCR reaction?
(A) act as the primary template for the synthesis of new DNA strands.
(B) serve as the basic building blocks for constructing the DNA strand.
(C) act as the enzymatic catalyst that drives the polymerase reaction.
(D) provide a 3'-OH end for DNA polymerase to initiate strand synthesis.

239. The main principle of AFLP is the selective PCR amplification of:
(A) various random segments of DNA throughout the whole genome.
(B) specific microsatellite and short tandem repeat regions of DNA.
(C) DNA fragments generated by specific restriction enzyme digestion.
(D) gene coding sequences (exons) present in the transcribed genome.

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240. Consider the following statements about vectors used in recombinant DNA technology:
I. Plasmids are small circular DNA molecules that replicate independently in bacteria.
II. BACs are used for cloning very large DNA fragments.
III. All vectors must contain an origin of replication to be maintained in the host.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

241. What type of microscopy would you use to observe the detailed 3D surface structure of a pollen grain?
(A) Scanning Electron Microscopy (SEM)
(B) Phase contrast microscopy
(C) Transmission Electron Microscopy (TEM)
(D) Fluorescence microscopy

242. The pH of a solution is defined as:
(A) the concentration of hydroxyl ions.
(B) the logarithm of the solution's conductivity.
(C) the ratio of acid to base in the solution.
(D) the negative logarithm of the hydrogen ion concentration.

243. The primary output of an X-ray crystallography experiment is a(n):
(A) amino acid sequence.
(B) electron density map.
(C) mass spectrum.
(D) absorption spectrum.

244. The key reagent in a Southern blot that allows for the detection of a specific DNA fragment is a:
(A) specific antibody.
(B) restriction enzyme.
(C) labeled DNA or RNA probe.
(D) DNA polymerase.

245. In vitro mutagenesis is a technique that allows researchers to:
(A) randomly mutate an entire eukaryotic or prokaryotic organism.
(B) analyze the quantitative expression of all genes in a single cell.
(C) isolate and purify all proteins from a cell lysate.

204. The principle of DNA fingerprinting relies on the fact that:
(A) the entire genomic sequence is identical among all individuals of a species.
(B) all genes are expressed at the same level in all individuals.
(C) specific regions of the genome are highly variable between unrelated individuals.
(D) the number of chromosomes is different for each person.

205. In the acronym RIA, what does the 'R' stand for?
(A) Recombinant
(B) Restriction
(C) Reporter
(D) Radioactive

206. A scanning electron microscope (SEM) provides a 3D-like image because it detects:
(A) secondary electrons emitted from the specimen's surface.
(B) electrons that have passed through the specimen.
(C) light that is scattered by the specimen.
(D) X-rays produced by the electron beam's interaction with the specimen.

207. Which of the following techniques would be best suited to determine if a protein is an alpha-helical protein or a beta-sheet protein in solution?
(A) X-ray crystallography
(B) SDS-PAGE
(C) Circular Dichroism (CD) Spectroscopy
(D) Mass spectrometry

208. The main difference between immunoprecipitation (IP) and co-immunoprecipitation (Co-IP) is that Co-IP is used to:
(A) purify a single target protein from a complex cell lysate.
(B) identify proteins that are interacting with the primary target.
(C) detect the simple presence of a specific protein in a sample.
(D) precipitate excess antibodies from a concentrated ionic solution.

209. GISH (Genomic in situ Hybridization) is particularly useful for:
(A) identifying the location of a single copy gene on a chromosome.
(B) studying the parental origin of chromosomes in hybrid plants.
(C) quantifying the amount of protein in a cell.
(D) creating gene knockouts in mice.

210. The following events occur during the creation of a recombinant plasmid:
I. Ligation of DNA insert into the vector.
II. Transformation of host cells.
III. Digestion of vector and insert DNA with the same restriction enzyme.
IV. Selection of transformed cells.
Which of the following is the correct chronological sequence?
(A) III, I, II, IV
(B) I, III, II, IV
(C) III, II, I, IV
(D) II, III, I, IV

211. Which of the following is NOT an application of PCR?
(A) Amplifying DNA for cloning.
(B) Forensic analysis of DNA samples.
(C) Diagnosing genetic diseases.
(D) Separating proteins by their isoelectric point.

212. What does the abbreviation IPR represent?
(A) Intellectual Property Rights.
(B) International Protocol on Research.
(C) Institutional Policies on Recombination.
(D) In-vivo Protein Regulation.

213. The role of the stationary phase in chromatography is to:
(A) carry the sample through the column using a specialized liquid buffer.
(B) detect the individual components as they elute from the end of the system.
(C) interact with mixture components to cause their individual separation.
(D) dissolve the sample completely before it is loaded onto the column head.

214. Which statement accurately distinguishes between Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM)?
(A) TEM provides surface topography, while

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257. What is the function of the enzyme DNA ligase in a cloning experiment?
(A) to cut the circular plasmid vector at specific recognition sites.
(B) to synthesize a completely new DNA strand from a given template.
(C) to allow the circular plasmid to enter the target bacterial host cell.
(D) to form phosphodiester bonds between the insert DNA and the vector.

258. The process of using living organisms, especially microorganisms, to degrade or remove environmental pollutants is known as:
(A) bioremediation.
(B) genetic engineering.
(C) fermentation.
(D) phytoremediation.

259. The 'Annealing' step in PCR involves:
(A) the separation of the two DNA strands.
(B) the synthesis of new DNA by polymerase.
(C) the binding of primers to the template DNA.
(D) the end of the PCR cycle.

260. A key ethical consideration in the use of genetic information is:
(A) potential for genetic discrimination in various employment or insurance.
(B) the significant financial cost of high-throughput DNA sequencing.
(C) the logistical difficulty in storing very large amounts of digital data.
(D) the technical choice of which specific sequencing technology to use.

261. The 'heavy metal' stains used in TEM, like osmium tetroxide and lead citrate, work by:
(A) imparting fluorescence to the sample.
(B) chemically preserving the sample's proteins.
(C) dissolving the lipid membranes for better viewing.
(D) being electron-dense and scattering the electron beam.

262. Which method would be best to confirm the successful integration of a transgene into a plant's genome?
(A) ELISA
(B) Southern Blotting
(C) Circular Dichroism
(D) Colorimetry

263. The primary role of a 'vector' in recombinant DNA technology is to:
(A) provide the enzymes needed for ligation.
(B) provide the host cell for replication.
(C) act as a carrier for the DNA sequence to be cloned.
(D) stain the DNA for visualization.

264. Given below are two statements:
Statement I: RAPD is a PCR-based technique that uses short, random primers.
Statement II: AFLP combines restriction digestion with PCR to generate DNA fingerprints.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

265. Match List-I with List-II regarding techniques and their primary separation principles.
List I: (Technique)
P. SDS-PAGE
Q. Isoelectric Focusing
R. Gel Filtration
S. Ion-Exchange Chromatography
List II: (Primary Separation Principle)
1. Charge
2. Size (Molecular Sieve)
3. Molecular Mass (in denaturing conditions)
4. Isoelectric Point
Choose the correct option:
(A) P-3, Q-4, R-2, S-1
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-1, R-2, S-4
(D) P-4, Q-3, R-1, S-2

266. Which technique directly measures mass-to-charge ratio of ions and can be used for sequencing peptides?
(A) NMR Spectroscopy
(B) Mass Spectrometry
(C) X-ray Crystallography
(D) UV-Visible Spectroscopy

267. The main purpose of creating a gene 'knock out' in an organism is:
(A) to over-express the functional protein

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224. Which technique allows for the quantitative analysis of different cell populations in a liquid sample?
(A) Western blotting
(B) Southern blotting
(C) Microtomy
(D) Flow cytometry

225. Surface Plasmon Resonance (SPR) directly measures changes in:
(A) refractive index changes near a sensor surface.
(B) variations in specific fluorescence intensity.
(C) flow of electrical current through a sample.
(D) absolute temperature of the reaction chamber.

226. The term 'fixation' in microscopy refers to the process of:
(A) securing the specimen to the microscope slide.
(B) preserving the cells and tissues in a life-like state.
(C) focusing the microscope to get a clear image.
(D) staining the specimen for better contrast.

227. In mass spectrometry, molecules are first converted into:
(A) crystals.
(B) ions.
(C) a colored solution.
(D) a solid precipitate.

228. Antibody generation is the process of producing antibodies in response to the introduction of a(n):
(A) antigen.
(B) epitope.
(C) hapten.
(D) adjuvant.

229. Large-scale expression analysis, such as that performed with microarrays, is also known as:
(A) proteomics.
(B) genomics.
(C) transcriptomics.
(D) metabolomics.

230. Match List-I with List-II regarding terms used in biotechnology and their definitions.
List I: (Term)
P. Recombinant DNA
Q. Plasmid
R. Transgenic Organism
S. PCR
List II: (Definition)
1. An organism containing a gene from another species
2. In vitro amplification of DNA
3. A DNA molecule created by joining DNA from different sources
4. A small, circular DNA molecule in bacteria
Choose the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

231. The purpose of using different speeds and durations in differential centrifugation is to:
(A) keep all internal organelles suspended in the liquid supernatant phase.
(B) lyse the cell membranes before beginning the separation procedures.
(C) sequentially pellet organelles of decreasing size and particle density.
(D) separate complex biomolecules based on their net surface electrical charge.

232. All of the following are physical methods for separation of biomolecules EXCEPT:
(A) Electrophoresis.
(B) Chromatography.
(C) Centrifugation.
(D) Western Blotting.

233. In situ hybridization is used to determine the:
(A) location of specific DNA or RNA sequences within a cell or tissue.
(B) total molecular weight and mass of a targeted cellular protein.
(C) enzymatic activity of a specific protein under various conditions.
(D) binding affinity and kinetics between two target biological molecules.

234. In the context of separation methods, isoelectric focusing separates molecules based on their:
(A) molecular weight.
(B) isoelectric point (pI).
(C) solubility.
(D) shape.

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279. The production of monoclonal antibodies involves fusing an antibody-producing B-cell with a:
(A) bacterial cell.
(B) T-helper cell.
(C) myeloma (cancerous plasma) cell.
(D) red blood cell.

280. The following steps are involved in creating a genetically modified plant using Agrobacterium:
I. Insert gene of interest into Ti-plasmid vector.
II. Transform Agrobacterium with the recombinant plasmid.
III. Co-culture Agrobacterium with plant tissue (e.g., leaf discs).
IV. Select and regenerate transformed plant cells into whole plants.
Which of the following represents the correct sequence?
(A) I, II, III, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) I, III, IV, II

281. The term 'DNA fingerprinting' was coined by:
(A) James Watson.
(B) Alec Jeffreys.
(C) Kary Mullis.
(D) Edwin Southern.

282. Which of the following is NOT an application of environmental biotechnology?
(A) development of diagnostic immunoassays like the standard ELISA.
(B) large-scale industrial production of various effective biopesticides.
(C) bioremediation of soils contaminated with toxic chemical pollutants.
(D) biological treatment of urban waste water within municipal systems.

283. What is the role of the enzyme reverse transcriptase?
(A) It synthesizes DNA from a DNA template.
(B) It synthesizes DNA from an RNA template.
(C) It synthesizes RNA from a DNA template.
(D) It synthesizes proteins from an RNA template.

284. A Northern blot is used to study:
(A) gene expression at the protein level.
(B) gene sequence variations.
(C) the 3D structure of a gene.
(D) gene expression at the RNA level.

285. In contrast to polyclonal antibodies, monoclonal antibodies:
(A) are produced by a single clone of cells and recognize a single epitope.
(B) recognize multiple epitopes on a single antigen.
(C) are a mixture of different antibodies.
(D) are less specific than polyclonal antibodies.

286. What is the primary purpose of a 'laminar air flow' cabinet in a biotechnology lab?
(A) To provide an oxygen-free environment.
(B) To maintain a sterile working area for cell culture.
(C) To safely handle radioactive materials.
(D) To incubate bacterial plates at 37°C.

287. Two proteins are separated by 2D gel electrophoresis. Protein A has a pI of 5.0 and a mass of 50 kDa. Protein B has a pI of 7.0 and a mass of 50 kDa. How will they be positioned relative to each other on the gel?
(A) They will be at the same horizontal position but A will be higher than B.
(B) They will be at the same vertical position but A will be to the left of B (acidic side).
(C) They will be at the same vertical position but B will be to the left of A (acidic side).
(D) They will be in the same spot.

288. The main ethical objection to patenting genes is the argument that:
(A) it amounts to ownership of life or fundamental products of nature.
(B) it is too expensive.
(C) it is not possible to describe a gene sequence.
(D) it stifles international collaboration.

289. The technique that uses fluorescent probes to detect specific DNA sequences on a chromosome is:
(A) Western Blot.
(B) RIA.
(C) FISH.
(D) GISH.

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ANSWERS

1. (B) Phase contrast microscopy
Phase contrast microscopy utilizes a specialized optical mechanism to translate minute variations in the refractive index and thickness of transparent specimens into corresponding changes in light amplitude. This process results in varying light intensities that enhance contrast without the need for chemical stains. It is particularly effective for viewing living cells in their natural state.

2. (A) It blocks direct light rays with a condenser so only scattered light enters the objective.
Dark field microscopy involves an illumination technique where the central light rays are blocked by a specialized condenser, allowing only oblique light to strike the specimen. The objective lens collects only the light scattered by the sample, making it appear bright against a dark background. This method is ideal for visualizing small, unstained particles and bacteria.

3. (C) Fluorescence microscopy
Fluorescence microscopy is a specialized technique that uses high-intensity light to excite fluorophores within a specimen. By using antibodies conjugated to fluorescent dyes, researchers can specifically target and visualize the precise location of proteins within complex cellular environments. The resulting emission of longer-wavelength light provides high contrast and specificity for detailed biological and molecular studies.

4. (A) Both A and R are true and R is the correct explanation of A.
The resolving power of a microscope is fundamentally limited by the wavelength of the radiation used to image the specimen. Electron microscopes achieve significantly higher resolution than light microscopes because the wavelength of an electron beam is much shorter than that of visible light. This physical property allows for the visualization of extremely small ultrastructural cellular details.

5. (C) the surface topography of a specimen.
Scanning electron microscopy is designed to provide detailed three-dimensional images of the surface features of a specimen. By scanning a focused electron beam across the sample and detecting secondary electrons emitted from its surface, the technique reveals intricate topographical details. It is widely used to study the external morphology and textures of various biological and inorganic samples.

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6. (A) Both Statement I and Statement II are true.
Transmission electron microscopy utilizes an electron beam that passes through an ultra-thin specimen to produce a detailed two-dimensional projection of internal structures. In contrast, scanning electron microscopy scans the surface of a sample with electrons to generate a three-dimensional effect. Both techniques provide significantly higher resolution and magnification than traditional light-based microscopic systems used in biological research.

7. (D) Ethanol
Chemical fixation is a critical step in preparing biological samples for electron microscopy to preserve their structural integrity. Standard agents used for this purpose include glutaraldehyde, which cross-links proteins, and osmium tetroxide, which stabilizes lipids. While ethanol is used as a dehydrating agent or for light microscopy, it is not considered a primary chemical fixative for electron microscopy.

8. (A) P-3, Q-4, R-1, S-2
Microscopic techniques are based on distinct physical principles to visualize specimens effectively. Freeze-etching involves fracturing frozen samples to reveal internal structures, while phase contrast uses refractive index differences for living cells. Scanning electron microscopy focuses on surface topography, and fluorescence microscopy utilizes fluorochromes to identify specific molecules. These diverse methods enable comprehensive and detailed analysis of cellular architecture.

299. In agriculture, biotechnology has led to the development of 'Roundup Ready' crops, which are:
(A) resistant to a common insect pest.
(B) fortified with extra vitamins.
(C) able to grow in high-salt soils.
(D) resistant to the herbicide glyphosate.

300. The final step in identifying a protein spot cut from a 2D gel is typically:
(A) sequencing the corresponding gene.
(B) analysis by mass spectrometry.
(C) running it on another 1D gel.
(D) staining it with a different dye.

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53. (C) variations in their repetitive DNA sequences.
DNA fingerprinting identifies individuals by analyzing specific regions of the genome that contain highly variable repetitive sequences, such as minisatellites or microsatellites. These patterns are unique to each person, except for identical twins. By comparing the length and distribution of these repeats through gel electrophoresis, forensic scientists and researchers can establish biological relationships and identify individuals with high precision.

54. (D) providing legal protection for inventions like gene sequences and GMOs.
Intellectual property rights in biotechnology provide legal mechanisms, such as patents, to protect original inventions and discoveries. This includes modified gene sequences, specialized laboratory techniques, and genetically modified organisms. These rights ensure that inventors can control the use and commercialization of their work, providing financial incentives that drive innovation and investment in the complex field of biotechnological research.

55. (C) using biological systems for remediation of contaminated environments and waste.
Environmental biotechnology focuses on the application of biological processes and organisms to address environmental challenges. This primarily involves bioremediation, where microorganisms or plants are used to degrade pollutants in soil and water. Additionally, it encompasses waste treatment and the development of sustainable biological solutions to minimize environmental impact and promote the restoration of ecosystems contaminated by hazardous industrial chemicals.

56. (B) Food industries
The food industry extensively utilizes biotechnology through the application of microorganisms like bacteria and yeast. In the production of yogurt and cheese, specific bacterial cultures ferment lactose into lactic acid, which preserves the food and develops its characteristic flavor and texture. This traditional form of biotechnology remains a cornerstone of modern industrial food processing and safety management systems worldwide.

57. (D) create a phase shift in the light passing through the specimen.
Phase contrast microscopy utilizes a specialized phase plate to alter the phase of light passing through a specimen relative to the background light. This interference creates contrast by converting phase differences, which the human eye cannot see, into visible variations in light intensity. This mechanism allows for the high-resolution observation of internal structures in unstained, living biological cells and tissues.

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58. (A) Phase Contrast Microscope - High resolution atomic structure
Different microscopic techniques serve specific purposes in biological research. While scanning electron microscopy reveals surface morphology and transmission electron microscopy shows internal ultrastructure, phase contrast microscopy is designed for viewing living cells. However, phase contrast microscopy cannot determine high-resolution atomic structures; such detailed structural information requires advanced biophysical methods like X-ray crystallography or high-resolution nuclear magnetic resonance spectroscopy.

59. (C) rapidly freezing the sample to preserve its structure in a near-native state.
Cryofixation is an advanced physical preservation method used in electron microscopy that involves the ultra-rapid freezing of biological specimens. By avoiding the formation of destructive ice crystals, this technique preserves cellular components in a state that closely resembles their living, native condition. It minimizes artifacts often introduced by traditional chemical fixatives, providing a more accurate representation of cellular architecture and organization.

60. (B) P-4, Q-1, R-2, S-3
Laboratory instruments perform specialized functions essential for biological analysis. Centrifuges separate components based on density, while colorimeters measure the concentration of colored solutions using light absorbance. pH meters determine hydrogen ion concentration for acidity monitoring, and microtomes are used to slice thin tissue sections for microscopy. Together, these tools enable researchers to isolate, quantify, and visualize various biological samples effectively.

9. (C) the arrangement of proteins within the lipid bilayer of cell membranes.
The freeze-fracture method is a specialized electron microscopy technique that involves rapidly freezing a sample and then cracking it open. This fracture often occurs along the hydrophobic interior of lipid bilayers, allowing for the direct visualization of the distribution and arrangement of integral membrane proteins. It provides unique and valuable insights into the three-dimensional organization of membranes.

10. (A) Image processing
Image processing involves the use of computational algorithms to enhance, analyze, and quantify digital images obtained from microscopic systems. This technique allows researchers to reduce background noise, improve contrast, and extract meaningful data from complex visual information. It is essential for modern biological research to ensure accurate interpretation and measurement of various cellular features and structural components.

11. (D) rate of migration in an electric field.
Electrophoresis is a fundamental laboratory technique used to separate charged biomolecules such as DNA, RNA, or proteins. This process occurs as these molecules migrate through a matrix toward an oppositely charged electrode when subjected to an electric field. The rate of migration depends on the net charge, size, and shape of the specific molecules being analyzed.

12. (D) I, II and III
Chromatography encompasses a diverse range of techniques used to separate mixtures into their individual components. It consistently employs a mobile phase and a stationary phase. Separation is achieved through the differential partitioning or affinity of the mixture's components between these two phases. This method is highly effective for purifying proteins, nucleic acids, and various other important biological molecules.

13. (C) Beer-Lambert Law.
The Beer-Lambert Law establishes a linear relationship between the absorbance of a solution and the concentration of the absorbing species. In colorimetry and spectrophotometry, this principle is used to quantify the amount of solute present by measuring the light intensity transmitted through a sample. It is a cornerstone for analytical chemistry and biochemical assays in laboratory settings.

14. (D) hydrogen ion activity in a solution.
A pH meter is an electronic instrument used to measure the acidity or alkalinity of a liquid. It functions by determining the hydrogen ion activity, which is expressed as the negative logarithm of the hydrogen ion concentration. This measurement is crucial in biological research, as many enzymatic and cellular processes are highly sensitive to even minor changes in pH.

15. (C) IV, II, III, I
Differential centrifugation separates cellular components based on their size and density through a series of increasingly faster spins. The process begins with a cell homogenate. Initially, low speeds pellet the largest components, like nuclei. Subsequent medium speeds isolate mitochondria and chloroplasts, while very high speeds are required to pellet smaller fragments such as microsomes and ribosomes.

16. (B) To cut extremely thin slices of tissue for microscopy.
A microtome is a high-precision mechanical instrument designed to cut extremely thin sections of biological tissues or materials. These thin slices are essential for light or electron microscopy, as they allow light or electrons to pass through the specimen for imaging. Proper sectioning ensures that internal cellular structures can be visualized clearly at high resolution and magnification.

17. (B) provide a sterile work area free of particulate contamination.
A laminar air flow cabinet creates a contaminant-free environment by directing filtered air in a steady, unidirectional stream across the work surface. This constant flow prevents room air and airborne particles from entering the enclosure. It is an indispensable tool in microbiology and cell culture for maintaining sterility during the manipulation of sensitive samples and growth media.

18. (A) Aromatic amino acids and nucleotide bases absorb UV light at specific wavelengths.
Ultraviolet spectroscopy is a reliable method for quantifying biomolecules based on their specific

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290. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Expression vectors for eukaryotic cells are often more complex than those for bacterial cells.
Reason (R): Eukaryotic expression requires elements like polyadenylation signals and may need components for post-translational modification, which are not present in bacteria.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

291. Which technique is most suitable for analyzing real-time interactions between an antibody and an antigen without any labels?
(A) ELISA
(B) Western blotting
(C) Immunoprecipitation
(D) Surface Plasmon Resonance (SPR)

292. The resolution of a light microscope is fundamentally limited by the:
(A) power of the electromagnetic lenses.
(B) wavelength of visible light.
(C) strength of the vacuum pump.
(D) speed of the centrifuge.

293. The purpose of SDS in SDS-PAGE is to:
(A) maintain the native conformation of proteins.
(B) stain the proteins for visualization.
(C) impart a uniform negative charge and denature proteins.
(D) buffer the electrophoresis system.

294. A researcher wants to study the global changes in gene expression in a cancer cell compared to a normal cell. The most appropriate large-scale technique would be:
(A) RFLP analysis.
(B) Southern blotting.
(C) Western blotting.
(D) Microarray analysis.

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295. Match List-I with List-II regarding scientists and their associated techniques.
List I: (Scientist)
P. Edwin Southern
Q. Kary Mullis
R. Georges Köhler & César Milstein
S. Alec Jeffreys
List II: (Associated Technique)
1. Monoclonal Antibody Production
2. DNA Fingerprinting
3. Southern Blotting
4. Polymerase Chain Reaction (PCR)
Choose the correct option:
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

296. A plasmid must contain which of the following to be useful as a cloning vector?
(A) telomeres and a functional centromere for genomic stability.
(B) an origin of replication, a selectable marker, and a cloning site.
(C) a reverse transcriptase gene to convert mRNA into a DNA copy.
(D) specialized 'cos' sites derived from a standard bacteriophage.

297. The term 'in situ' means:
(A) in its original place.
(B) in a test tube.
(C) in a living organism.
(D) in a computer simulation.

298. Consider the following statements regarding microscopic techniques:
I. SEM provides a high-resolution view of a specimen's surface.
II. TEM provides a high-resolution view of a specimen's internal structures.
III. Phase contrast microscopy is used for viewing living cells without staining.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

27. (D) type of label used for detection, such as enzymes or isotopes.
Both enzyme-linked immunosorbent assays and radioimmunoassays are competitive binding techniques used to detect antigens with high specificity. The primary difference lies in the signaling method employed for detection. The former uses enzyme-linked antibodies to produce a colorimetric signal, while the latter relies on radioactively labeled isotopes. Each method offers distinct advantages regarding sensitivity, safety, and laboratory equipment requirements.

28. (B) Proteins in a sample.
Western blotting, or immunobloting, is a fundamental technique used to detect specific proteins within a complex biological sample. It involves separating proteins by size using gel electrophoresis, followed by their transfer to a solid membrane. Targeted proteins are then identified using specific antibodies, allowing researchers to determine the presence, relative abundance, and molecular weight of the protein of interest.

29. (C) DNA sequences.
Southern blotting is a cornerstone molecular biology technique used to detect specific DNA sequences within a complex genomic sample. It combines gel electrophoresis for size separation with the transfer of DNA to a membrane and hybridization with a labeled DNA probe. This method is essential for gene mapping, forensic analysis, and identifying specific genetic variations or mutations across individuals.

30. (A) P-3, Q-4, R-1, S-2
Blotting techniques are essential for identifying specific molecules within complex biological mixtures. Southern blotting is designed for DNA detection, while Northern blotting targets RNA sequences. Western blotting utilizes antibodies to identify specific proteins, and Eastern blotting is used for analyzing post-translational modifications. These methods provide high specificity and sensitivity for molecular analysis in various research and clinical laboratory applications.

31. (A) isolate a specific protein from a complex mixture using a targeted antibody.
Immunoprecipitation is a technique used to isolate and concentrate a specific protein from a complex mixture, such as a cell lysate. It involves using an antibody that binds specifically to the target protein, followed by the precipitation of the resulting antibody-antigen complex. This method is often used to study protein expression, purification, and protein-protein interactions within cells.

32. (B) Flow cytometry
Flow cytometry is a powerful technology used to analyze the physical and chemical characteristics of individual cells as they pass through a focused laser beam. By using fluorescently labeled antibodies against specific surface markers, it can sort and quantify different cell types from a mixed population. This technique provides rapid, high-throughput, and multi-parametric analysis of various complex biological samples.

33. (B) Fluorescence In Situ Hybridization (FISH).
Fluorescence in situ hybridization is a molecular cytogenetic technique that utilizes fluorescently labeled DNA probes to detect and localize specific DNA sequences on chromosomes. It allows for the direct visualization of genetic material within fixed cells or tissues. This method is invaluable for mapping genes, identifying chromosomal abnormalities, and studying the spatial organization of the genome in nuclei.

34. (A) distinguish between chromosomes from different parental species in a hybrid.
Genomic in situ hybridization is a specialized form of hybridization that uses total genomic DNA from one species as a probe to identify its chromosomes within a hybrid or polyploid genome. It is particularly useful in plant breeding and evolutionary studies to distinguish between the contributions of different parental species. This technique provides insights into chromosomal composition and genome evolution.

35. (D) I, II and III
Immunodetection techniques utilize the high specificity of antibodies to identify and study various biological molecules. ELISA uses enzyme-conjugated antibodies for quantitative detection,

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while Western blotting transfers separated proteins to a membrane for identification. Immunoprecipitation allows for the purification of specific antigens from complex solutions. Together, these methods form a comprehensive toolkit for analyzing protein expression and molecular interactions.

36. (D) make specific, targeted changes to a DNA sequence.
Site-directed mutagenesis is a sophisticated molecular biology technique used to introduce specific, predetermined changes into a DNA sequence. This targeted approach allows researchers to study the functional importance of individual amino acids in a protein or specific regulatory elements in a gene. It is a fundamental tool for understanding structure-function relationships and performing precise genetic engineering.

37. (C) one of an organism's genes is made inoperative.
A gene knockout is a genetic technique in which an organism's gene is intentionally made inoperative or "knocked out." This is typically achieved through homologous recombination or gene-editing technologies like CRISPR. By observing the resulting phenotype in the absence of the gene's function, researchers can determine the specific biological role and importance of that gene within the organism.

38. (B) large-scale analysis of gene expression.
Microarray-based techniques utilize thousands of immobilized DNA probes to simultaneously monitor the expression levels of many genes in a single experiment. By hybridizing labeled cDNA or cRNA from a sample to the array, researchers can obtain a comprehensive profile of which genes are active under specific conditions. This high-throughput method is essential for transcriptomics and comparative genomics.

39. (D) Sanger sequencing
Lipid analysis typically involves techniques that separate and identify diverse fat molecules based on their chemical properties. Gas chromatography and thin-layer chromatography are common methods for separation, while mass spectrometry provides detailed information on molecular structure and mass. In contrast, Sanger sequencing is a specialized method used exclusively for determining the nucleotide sequence of DNA molecules, not lipids.

40. (A) digesting DNA with restriction enzymes and analyzing fragment size variations.
Restriction fragment length polymorphism analysis involves the digestion of DNA with specific restriction enzymes, followed by gel electrophoresis to separate the resulting fragments. Variations in the DNA sequence among individuals can create or abolish restriction sites, leading to fragments of different lengths. This technique is used for genetic mapping, identifying disease-related genes, and performing forensic DNA profiling.

41. (C) They use short, arbitrary primers to amplify random DNA segments.
Random amplified polymorphic DNA is a PCR-based technique that uses short, arbitrary primers to amplify random segments of genomic DNA. Because the primers are non-specific, they bind to multiple sites across the genome, producing a unique pattern of amplified fragments. This method does not require prior knowledge of the DNA sequence, making it useful for genetic diversity studies.

42. (A) RFLP and PCR.
Amplified fragment length polymorphism is a highly sensitive DNA fingerprinting technique that combines the specificity of restriction enzyme digestion with the power of PCR amplification. It involves digesting genomic DNA, ligating specialized adapters, and then selectively amplifying specific fragments. This method provides high resolution and reproducibility, making it ideal for genetic mapping and biodiversity analysis across diverse species.

43. (D) Alkaline lysis method
The alkaline lysis method is a standard procedure for isolating plasmid DNA from bacterial cells. It involves using a basic solution to denature both genomic and plasmid DNA, followed by rapid neutralization. While the large genomic DNA remains insoluble and precipitates with cellular debris, the smaller, circular plasmid DNA successfully renatures and remains in the supernatant for further purification and study.

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44. (B) Isoelectric point and molecular weight.
Two-dimensional gel electrophoresis is a powerful technique for separating complex protein mixtures. In the first dimension, proteins are separated by their isoelectric point using a pH gradient. In the second dimension, they are separated by their molecular weight using SDS-PAGE. This dual separation provides significantly higher resolution than one-dimensional methods, allowing for the identification of thousands of individual proteins.

45. (A) Both A and R are true and R is the correct explanation of A.
Complementary DNA libraries are constructed by isolating messenger RNA from a cell and using the enzyme reverse transcriptase to synthesize corresponding DNA copies. Since mRNA represents only the genes being actively transcribed, the resulting cDNA library reflects the expressed portion of the genome. This makes it a valuable tool for studying gene expression patterns and cloning coding sequences.

46. (C) overall charge in a pH gradient.
Isoelectric focusing is an electrophoretic technique used to separate proteins based on their unique isoelectric point. Proteins migrate through a stable pH gradient established in a gel until they reach the pH where their net electrical charge is zero. At this point, they stop moving, resulting in sharp bands. This high-resolution method is often used for analyzing protein isoforms and purity.

47. (D) ligation.
Ligation is the essential molecular process of joining two DNA fragments together by forming phosphodiester bonds. In recombinant DNA technology, the enzyme DNA ligase is used to permanently insert a target DNA fragment into a linearized vector, such as a plasmid. This step is critical for creating stable recombinant molecules that can be introduced into host cells for replication.

48. (A) Both Statement I and Statement II are true.
Genomic DNA libraries contain the entire genetic blueprint of an organism, including both coding and non-coding regions such as introns and regulatory elements. In contrast, cDNA libraries are derived from messenger RNA and represent only the exons of genes being actively expressed at a specific time. Both types of libraries are fundamental tools for different applications in genetic and molecular research.

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49. (A) Yeast Artificial Chromosome (YAC)
Yeast artificial chromosomes are specialized cloning vectors designed to carry extremely large fragments of foreign DNA, often ranging from hundreds of thousands to over a million base pairs. They include essential components for chromosomal stability in yeast, such as telomeres, centromeres, and origins of replication. This large capacity makes them indispensable for mapping complex genomes and constructing large-scale genomic libraries.

50. (B) produced from a cloned gene in a host system.
A recombinant protein is a protein that is generated by transcribing and translating a cloned gene within a foreign host organism, such as bacteria, yeast, or animal cells. By using recombinant DNA technology, researchers can produce large quantities of specific proteins that may be difficult to isolate from natural sources. These proteins are widely used in medicine, industry, and biological research.

51. (B) To amplify a specific segment of DNA exponentially.
The polymerase chain reaction is a fundamental molecular biology technique used to amplify a specific segment of DNA into millions of copies. Through repeated cycles of denaturation, primer annealing, and enzymatic extension, a targeted sequence is doubled in each step. This exponential amplification allows for the detection and analysis of DNA even from very small or degraded biological samples.

52. (A) complete immunity to all physical damage.
Agricultural biotechnology has successfully developed crops with improved traits such as enhanced nutritional content, resistance to specific insect pests, and tolerance to certain herbicides. These advancements contribute to higher yields and reduced chemical usage. However, creating plants with complete immunity to all forms of physical damage is not currently possible through genetic engineering or any other known biological modification method.

light absorption properties. Proteins exhibit a characteristic absorbance peak at 280 nanometers due to aromatic amino acids like tryptophan and tyrosine. Similarly, nucleic acids absorb strongly at 260 nanometers because of their nitrogenous bases. These unique absorbance profiles allow for accurate concentration measurements.

19. (C) determining secondary structure content like alpha-helices and beta-sheets.
Circular dichroism spectroscopy is a powerful biophysical tool used to analyze the secondary structure of proteins and other chiral molecules. It measures the differential absorption of left and right circularly polarized light. The resulting spectra provide characteristic signatures for structural motifs such as alpha-helices, beta-sheets, and random coils, allowing researchers to monitor protein folding and stability.

20. (A) Both A and R are true and R is the correct explanation of A.
Nuclear magnetic resonance spectroscopy is an advanced technique used to determine the three-dimensional structures of proteins and other macromolecules in solution. It provides detailed information about the chemical environment of atomic nuclei and the distances between specific atoms. By calculating these interatomic distances, researchers can reconstruct the precise folding and spatial arrangement of the entire molecular structure.

21. (C) The environment of unpaired electrons in a molecule.
Electron spin resonance spectroscopy, also known as electron paramagnetic resonance, is a technique used to study substances containing unpaired electrons. It provides detailed information about the local chemical environment, electronic structure, and dynamics of paramagnetic centers. This method is particularly useful for investigating free radicals, certain transition metal complexes, and the active sites of specific metalloenzymes.

22. (B) X-ray crystallography.
X-ray crystallography is currently the most definitive biophysical method for determining the high-resolution three-dimensional atomic structure of biomolecules. It involves the diffraction of X-rays by a crystallized sample, followed by the analysis of the resulting pattern. This technique provides precise information regarding the spatial arrangement of atoms within proteins and other complex macromolecular assemblies in their crystalline state.

23. (D) It requires the sample to be in a crystalline form.
Mass spectrometry is a versatile analytical technique that measures the mass-to-charge ratio of ions to determine molecular weight and identify chemical structures. Unlike X-ray crystallography, it does not require samples to be in a crystalline form; instead, molecules are ionized and analyzed in the gas phase. It is widely used for protein identification and sequencing peptides with high sensitivity.

24. (A) analyze real-time biomolecular interactions.
Surface plasmon resonance is a highly sensitive optical technique used to monitor biomolecular interactions in real-time without the need for labels. It detects changes in the refractive index near a metal surface when molecules bind to an immobilized ligand. This method provides critical data on binding kinetics, affinity, and specificity for a wide variety of biological molecular complexes.

25. (C) injecting an antigen into an animal to trigger a specific immune response.
The production of antibodies for immunotechniques generally begins by injecting a target antigen into a host animal, such as a rabbit or mouse. The animal's immune system recognizes the antigen as foreign and produces specific antibodies through B-cell activation. These antibodies can then be harvested from the animal's serum for use in various diagnostic and research applications.

26. (A) It uses enzyme-linked antibodies to produce a color change for antigen detection.
The enzyme-linked immunosorbent assay is a widely used biochemical technique for detecting and quantifying specific antigens or antibodies in a sample. It utilizes antibodies conjugated to enzymes that catalyze a reaction resulting in a detectable color change. This method is highly sensitive and versatile, making it a standard tool in clinical diagnostics and various biological research projects.

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61. (D) Nuclear Magnetic Resonance (NMR)
Nuclear magnetic resonance spectroscopy is an analytical technique that exploits the magnetic properties of certain atomic nuclei. When placed in a strong magnetic field and exposed to radiofrequency radiation, these nuclei absorb energy at specific frequencies. The resulting spectra provide detailed information about the chemical environment, connectivity, and three-dimensional structure of molecules, making it a vital tool for studying complex biological macromolecules.

62. (B) size and shape.
Light scattering techniques are used to characterize biomolecules by measuring how they deflect a beam of light. The intensity and pattern of the scattered light provide critical information regarding the molecular weight, size, and overall shape of the particles in solution. This non-destructive method is particularly valuable for studying protein aggregation, polymer size distribution, and the hydrodynamic properties of complex macromolecules.

63. (C) The scattering of X-rays by the electron clouds of atoms in a crystal lattice.
X-ray crystallography determines molecular structure by analyzing the diffraction pattern produced when a beam of X-rays strikes a crystallized sample. The X-rays are scattered by the electron clouds surrounding the atoms within the crystal lattice. By mathematically processing these scattering patterns, researchers can calculate an electron density map and build a precise three-dimensional model of the molecule's atomic arrangement.

64. (D) Matrix-Assisted Laser Desorption/Ionization
Matrix-assisted laser desorption/ionization is a soft ionization technique used in mass spectrometry for the analysis of large biomolecules such as proteins and polymers. The sample is embedded in a specialized matrix that absorbs laser energy, facilitating the desorption and ionization of the molecules without significant fragmentation. This method allows for the accurate measurement of high molecular weights in complex biological samples.

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65. (D) I, II and III
Spectroscopic techniques are essential for the analysis of biomolecules. UV spectroscopy quantifies nucleic acids at 260 nm, while circular dichroism is used to determine the secondary structure content of proteins. Additionally, nuclear magnetic resonance can resolve the three-dimensional structure of small proteins in a solution state. Collectively, these methods provide comprehensive data regarding the concentration, folding, and spatial organization of biological macromolecules.

66. (A) recognize multiple epitopes on a single antigen.
Polyclonal antibodies are a heterogeneous mixture of immunoglobulins produced by multiple B-cell clones in response to a single antigen. Because an antigen typically has several different epitopes, the resulting antiserum contains a variety of antibodies that each recognize a different part of the molecule. This broad recognition makes polyclonal antibodies highly effective for various detection and diagnostic immunotechniques in biological research.

67. (B) the secondary antibody.
In an indirect ELISA, the primary antibody binds specifically to the target antigen immobilized on a surface. A secondary antibody, which is conjugated to a reporter enzyme, is then added to recognize and bind the primary antibody. This indirect detection method amplifies the signal and allows for greater flexibility, as a single labeled secondary antibody can be used for many different primary antibodies.

68. (B) preventing non-specific binding of antibodies to the solid support.
The blocking step is a critical phase in immunodetection techniques like ELISA and Western blotting. It involves treating the solid support, such as a plastic well or membrane, with a concentrated protein solution like BSA or non-fat milk. This process occupies any remaining binding sites on the surface, ensuring that antibodies bind only to their specific targets and not non-specifically to the support.

69. (A) a reverse transcriptase enzyme.
Western blot analysis is a multi-step procedure used to identify specific proteins. It requires SDS-

face a significant limitation regarding their reproducibility. Because the technique relies on short, arbitrary primers and low annealing temperatures, minor variations in laboratory conditions, such as reagent concentration or thermal cycler performance, can lead to different banding patterns. This makes it challenging to compare results across different laboratories or even between different experimental runs.

103. (C) Chromatin Immunoprecipitation (ChIP)
Chromatin immunoprecipitation is a specialized technique used to investigate the interactions between proteins and DNA within a living cell. It involves cross-linking proteins to DNA, fragmenting the chromatin, and then using specific antibodies to pull down the target protein along with its associated DNA sequences. This method is essential for identifying the specific binding sites of transcription factors and other DNA-binding proteins across the genome.

104. (D) Southern blotting.
Southern blotting is a fundamental procedure that involves the transfer of DNA fragments from an electrophoresis gel to a solid support, such as a nylon or nitrocellulose membrane. This transfer, or "blotting," preserves the relative positions of the DNA fragments as they were separated by size. Once immobilized on the membrane, the DNA can be hybridized with specific probes to identify and analyze targeted sequences.

105. (C) Bacteriophage lambda
A cosmid is a specialized hybrid cloning vector that combines the essential features of a bacterial plasmid with the 'cos' sites derived from bacteriophage lambda. These 'cos' sites allow the recombinant DNA to be packaged into viral particles, facilitating the efficient delivery of large DNA fragments into host bacteria. Cosmids can carry significantly larger inserts than standard plasmids, making them useful for genomic library construction.

106. (B) It allows for the identification of cells that have successfully taken up the plasmid.
A selectable marker is a gene included in a cloning vector that confers a specific trait, such as antibiotic resistance, to the host cell. This allows researchers to easily distinguish and select only those cells that have successfully undergone transformation and contain the plasmid. By growing the cells on media containing the antibiotic, only the transformed individuals will survive and form colonies for further study.

107. (D) healthcare.
The production of human insulin in genetically engineered bacteria is a landmark achievement in healthcare biotechnology. Before this advancement, insulin was primarily harvested from the pancreases of cattle or pigs, which could cause allergic reactions in some patients. Recombinant DNA technology allows for the mass production of pure human insulin, providing a safer and more reliable treatment for millions of people with diabetes worldwide.

108. (A) Profitability (ensuring financial gain)
Biotechnology ethics are guided by core bioethical principles designed to ensure responsible and fair research and application. These include non-maleficence, which mandates doing no harm, and beneficence, which focuses on providing benefits. Justice ensures the fair distribution of resources and advancements. While commercial success is often a result of innovation, profitability is not considered a fundamental ethical principle guiding the conduct of biological research.

109. (C) Sedimentation (Centrifugation)
Sedimentation, commonly achieved through centrifugation, is a separation method based on the behavior of particles in a liquid medium when subjected to gravitational or centrifugal forces. Particles move at different rates depending on their mass, density, and shape. This technique is widely used in laboratories to isolate specific cellular organelles, separate cells from plasma, and purify macromolecules based on their physical properties and sedimentation coefficients.

110. (A) separate the excitation light from the emitted fluorescence signal.
In fluorescence microscopy, a dichroic mirror is a specialized filter that selectively reflects certain wavelengths of light while allowing others to pass through. It reflects the shorter-wavelength excitation light onto the specimen to excite the fluorophores. Simultaneously, it permits the longer-wavelength emitted fluorescence from the sample to pass through toward the detector,

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DNA into plant cells. Biotechnology exploits this mechanism by using modified Ti plasmids from Agrobacterium as vectors to deliver recombinant genes into various plant species. This method has become a cornerstone of plant genetic engineering, allowing for the stable integration and expression of foreign traits in agricultural crops.

79. (A) partially digesting total genomic DNA and cloning fragments into vectors.
Constructing a genomic library involves the isolation of total genomic DNA from an organism, followed by partial digestion with restriction enzymes to produce overlapping fragments. These fragments are then ligated into suitable cloning vectors and introduced into host cells. The resulting collection of clones ideally represents every DNA sequence present in the organism's genome, providing a permanent resource for genetic analysis and gene isolation.

80. (A) Both A and R are true and R is the correct explanation of A.
Restriction fragment length polymorphism analysis relies on the fact that individuals within a species have unique DNA sequences. These variations can create, destroy, or shift the position of recognition sites for restriction enzymes. When DNA is digested, the resulting fragments will vary in length between individuals, producing distinct patterns on a gel. These polymorphisms are used as valuable genetic markers for mapping and identification.

81. (B) the production of micropropagation-based disease-free planting material.
In horticulture, biotechnology is extensively applied through micropropagation, a tissue culture technique used to rapidly clone plants. This process allows for the large-scale production of uniform, disease-free planting material from a single parent plant. By maintaining sterile conditions and using specific growth regulators, researchers can ensure high-quality crops, which is essential for commercial nurseries and the global trade of ornamental and fruit-bearing species.

82. (A) the patenting of life forms and genetic determinism.
Ethical discussions in biotechnology often focus on the profound implications of manipulating genetic material. Key concerns include the ethics of patenting living organisms or gene sequences, which some argue restricts access to natural information. Additionally, issues such as genetic determinism and the potential for discrimination based on genetic profiles are central to the debate, requiring careful regulation to protect individual rights and promote social justice.

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83. (C) Recombinant DNA technology
Recombinant DNA technology is the fundamental cornerstone of modern plant genetic engineering. It enables scientists to isolate specific genes from any source and precisely introduce them into the genome of a plant. This process creates transgenic plants with desirable new traits, such as improved nutritional value or resistance to environmental stress. This technology has revolutionized agriculture by providing tools for precise and targeted crop improvement.

84. (D) Denaturation, Annealing, Extension.
A single cycle of the polymerase chain reaction consists of three distinct, temperature-dependent steps. First, denaturation uses high heat to separate the double-stranded DNA template. Second, annealing allows primers to bind to their complementary sequences as the temperature is lowered. Finally, extension involves a DNA polymerase synthesizing new strands by adding nucleotides. Repeating these cycles results in the exponential amplification of the target DNA sequence.

85. (C) The electromagnetic lens
In an electron microscope, electromagnetic lenses perform a function analogous to the glass lenses found in light microscopes. While glass lenses bend light rays to focus an image, electromagnetic lenses use magnetic fields to deflect and focus the beam of electrons. These lenses are essential for controlling the electron path and achieving the high magnification and resolution characteristic of electron-based imaging systems.

PAGE for size separation, the transfer of proteins to a membrane, and the use of primary antibodies for targeted detection. While these components are essential, reverse transcriptase is an enzyme used to synthesize DNA from an RNA template and is not required for the detection of proteins in a Western blot.

70. (C) in situ hybridization.
In situ hybridization is a powerful technique that allows for the detection and localization of specific nucleic acid sequences directly within a tissue section or whole organism. By using labeled DNA or RNA probes that are complementary to the target sequence, researchers can visualize the spatial and temporal patterns of gene expression. This method provides critical context for understanding biological processes in their native environment.

71. (D) size.
In flow cytometry, forward scatter is a measurement of the light that is deflected at small angles as a cell passes through a laser beam. The intensity of this signal is primarily proportional to the overall size or cross-sectional area of the cell. By analyzing forward scatter, researchers can distinguish between different cell populations based on their physical dimensions in a heterogeneous biological sample.

72. (A) Homologous recombination
Gene knockout technology in eukaryotic organisms frequently relies on homologous recombination, a natural cellular process for repairing DNA. By introducing a DNA construct with sequences identical to those flanking the target gene, researchers can induce the cell to replace the functional gene with an inactive version. This precise replacement allows for the permanent silencing of a specific gene to study its biological function.

73. (C) is more reproducible.
Amplified fragment length polymorphism is often preferred over random amplified polymorphic DNA because of its superior reproducibility and reliability. While RAPD uses short, arbitrary primers that can lead to inconsistent results, AFLP utilizes specific adapters and selective primers following restriction enzyme digestion. This rigorous approach provides highly consistent and detailed DNA fingerprints, making it more suitable for complex genetic mapping and diverse evolutionary studies.

74. (A) molecular mass.
In SDS-PAGE, proteins are treated with sodium dodecyl sulfate, which denatures them and imparts a uniform negative charge proportional to their length. This ensures that all proteins have the same charge-to-mass ratio and adopt a similar linear shape. Consequently, when subjected to an electric field within a polyacrylamide gel, the proteins are separated almost exclusively based on their individual molecular mass.

75. (A) I, III, II, IV
Cloning vectors differ significantly in their capacity to carry foreign DNA inserts. Plasmids typically hold the smallest inserts, followed by cosmids which are specialized hybrids. Bacterial artificial chromosomes can accommodate much larger fragments, up to several hundred thousand base pairs. Yeast artificial chromosomes possess the highest capacity, making them suitable for cloning fragments over a million base pairs long for large-scale genomic mapping projects.

76. (B) Reverse transcriptase.
Reverse transcriptase is a specialized enzyme that catalyzes the synthesis of a complementary DNA strand from an RNA template. This process is essential for the replication of retroviruses and is widely utilized in molecular biology to create cDNA libraries from messenger RNA. By converting unstable RNA into stable DNA, researchers can amplify and analyze the sequences representing actively expressed genes.

77. (C) Agrose
Cloning vectors are DNA molecules used to carry and replicate foreign genetic material in host cells. Common examples include plasmids, bacteriophages, and cosmids, each with specific features for different insert sizes. In contrast, agarose is a polysaccharide derived from seaweed used to create gels for the electrophoretic separation of nucleic acids. It is a support medium for separation, not a biological vector for cloning.

78. (D) Agrobacterium tumefaciens.
Agrobacterium tumefaciens is a soil bacterium naturally capable of transferring a segment of its

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94. (D) bioremediation.
Bioremediation is the application of biological organisms, such as bacteria or fungi, to neutralize or remove pollutants from a contaminated site. An example is the use of genetically engineered or specialized naturally occurring bacteria to break down complex hydrocarbons in oil spills. This sustainable approach utilizes natural metabolic processes to restore environmental health, offering an effective alternative to traditional chemical and physical cleanup methods.

95. (C) P-4, Q-1, R-2, S-3
Molecular markers are essential tools for genetic analysis, each possessing unique characteristics. RFLP identifies variations in restriction sites, while RAPD uses short, random primers for amplification. AFLP selectively amplifies restriction fragments to provide high resolution. Microsatellites focus on tandem repeats of short nucleotide sequences. Together, these markers allow researchers to map genomes, study genetic diversity, and perform forensic identification with high precision.

96. (B) Dark field microscopy
Dark field microscopy utilizes a specialized illumination system that prevents direct light from entering the objective lens. Only the light that is scattered or reflected by the specimen is collected, resulting in an image where the sample appears brightly illuminated against a completely dark background. This technique is particularly useful for observing small, unstained objects or thin biological structures that lack sufficient contrast in bright field microscopy.

97. (A) Both Statement I and Statement II are true.
Osmium tetroxide is a versatile reagent in electron microscopy, serving as both a primary fixative and an electron-dense stain. It reacts specifically with the unsaturated bonds of lipids, effectively stabilizing cellular membranes. Because osmium is a heavy metal, it scatters electrons, making the membranes appear dark and clearly visible. This dual action is essential for preserving and visualizing the intricate internal architecture of cells.

98. (A) distinguish between two closely spaced points as separate entities.
Resolving power is the most critical parameter of a microscope, defined as its ability to distinguish two closely situated objects as separate points. It determines the level of detail that can be observed in an image. While magnification increases the size of an object, high resolution is required to see the fine structure. Resolution is fundamentally limited by the wavelength of light or electrons used for imaging.

99. (C) elute from the column last.
In chromatography, the separation of components depends on their varying affinities for the mobile and stationary phases. A molecule that interacts more strongly with the stationary phase will be retained longer within the column as the mobile phase flows through. Consequently, these strongly interacting components will travel more slowly and elute from the end of the system last, behind molecules with weaker interactions.

100. (D) I, II and III
The polymerase chain reaction is a robust technique that requires a thermostable DNA polymerase to withstand repeated heating to approximately 95°C for DNA denaturation. While PCR is designed to amplify DNA, it cannot amplify RNA directly. For RNA analysis, a preliminary step using reverse transcriptase is required to convert the RNA into complementary DNA, which then serves as the template for amplification.

101. (B) They help differentiate between and identify connected protons.
Advanced nuclear magnetic resonance techniques, such as 2D-NMR and NOESY, are essential for resolving complex molecular structures. These methods provide information about the connectivity and spatial proximity of atomic nuclei, particularly protons, within a molecule. By observing how these nuclei interact through bonds or through space, researchers can determine the precise three-dimensional folding and atomic arrangement of proteins and other large biological macromolecules.

102. (A) They often suffer from poor reproducibility.
Random amplified polymorphic DNA markers are useful for genetic screening but

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DNA denaturation. This property revolutionized the polymerase chain reaction by eliminating the need to add fresh enzyme after every heating cycle, making the process efficient and easily automated.

119. (B) a promoter recognized by the host's RNA polymerase.
While simple cloning vectors are designed for the replication and maintenance of DNA, expression vectors are specifically engineered to produce the protein product of the cloned gene. The key feature of an expression vector is a strong, often inducible, promoter that is recognized by the host cell's transcription machinery. This ensures that the inserted gene is efficiently transcribed into mRNA and subsequently translated into a functional protein.

120. (D) 2D-Gel Electrophoresis and Mass Spectrometry.
Comparing the entire proteome of cells under different conditions requires a combination of high-resolution separation and precise identification. Two-dimensional gel electrophoresis separates thousands of proteins based on their charge and size, allowing researchers to observe changes in protein abundance. Subsequently, mass spectrometry is used to identify the specific proteins within the individual spots. Together, these techniques provide a comprehensive view of global protein expression patterns.

121. (A) breaking down the cellulose cell wall via enzymatic or mechanical means.
Isolating DNA from plant cells requires an additional initial step compared to animal cells because plants possess a rigid cell wall composed primarily of cellulose. This wall must be physically or enzymatically disrupted to release the cellular contents. Common methods include grinding the tissue in liquid nitrogen or using cellulase enzymes. Once the wall is broken, standard lysis and purification procedures can follow to isolate the DNA.

122. (C) remove one or more nucleotide bases from a DNA sequence.
In vitro mutagenesis encompasses various techniques used to modify DNA sequences for functional studies. A deletion technique specifically involves the removal of one or more nucleotide bases from a target gene. By creating these specific gaps in the genetic code, researchers can determine if the missing sequence is essential for the stability, folding, or enzymatic activity of the resulting protein, helping to map critical functional domains.

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123. (D) detecting a molecule in its original position within the cell.
In situ localization refers to a set of techniques used to detect and visualize biological molecules, such as DNA, RNA, or proteins, exactly where they are located within a cell or tissue. By preserving the structural context, these methods provide critical information about the spatial distribution and organization of molecules. This is often achieved through hybridization or antibody binding on fixed specimens, allowing for high-resolution spatial analysis.

124. (B) total genomic DNA from one species as a probe to identify origins.
Genomic in situ hybridization is a specialized application that uses total genomic DNA from one species as a fluorescent probe to distinguish its chromosomes within a hybrid or polyploid genome. In contrast, standard FISH typically uses smaller, more specific DNA probes to target individual genes or chromosomal regions. GISH is particularly valuable in evolutionary biology and plant breeding for identifying the parental origin of genetic material.

125. (B) P-3, Q-4, R-1, S-2
Biological techniques provide diverse applications for cellular and molecular analysis. Flow cytometry sorts cells based on surface markers, while surface plasmon resonance analyzes real-time molecular binding kinetics. Circular dichroism is used to determine protein secondary structures, and X-ray crystallography provides high-resolution three-dimensional atomic structures. Together, these methods form an essential toolkit for modern biophysical research, enabling the detailed study of biological systems at multiple levels.

126. (D) Mass, density, and shape
Centrifugation is a physical separation technique that exploits the differences in mass, density, and shape of particles in a suspension. When a sample

effectively separating the signal from the background illumination for clear imaging.

111. (D) It avoids potential artifacts caused by chemical reactions.
Freeze-etching is a physical preservation technique for electron microscopy that offers a significant advantage over traditional chemical fixation. By rapidly freezing a specimen, it captures cellular structures in a near-native state without the use of chemical reagents that can cause shrinkage, cross-linking, or structural distortion. This method provides a more accurate representation of membrane organization and internal cellular architecture, reducing the risk of laboratory-induced artifacts.

112. (B) Yeast Two-Hybrid system or Co-Immunoprecipitation.
Studying protein-protein interactions is essential for understanding cellular signaling and metabolic pathways. The Yeast Two-Hybrid system is a powerful genetic tool used to detect interactions between pairs of proteins in vivo. Similarly, co-immunoprecipitation utilizes antibodies to pull down a target protein along with any other proteins physically bound to it. Both techniques provide critical insights into the complex molecular networks that drive various biological functions.

113. (C) immobilized single-stranded DNA probes in an ordered array.
A microarray, often called a gene chip, consists of thousands of distinct single-stranded DNA probes immobilized in a precise, high-density array on a solid surface like glass. These probes represent specific genes from an organism's genome. When labeled nucleic acids from a sample are hybridized to the chip, the resulting patterns of binding allow researchers to simultaneously analyze the expression levels of thousands of genes.

114. (D) HPLC and high-resolution Mass Spectrometry.
The analysis of carbohydrates is complex due to their diverse structures and lack of characteristic UV absorbance. High-performance liquid chromatography is commonly used to separate different sugar molecules with high resolution. Subsequently, mass spectrometry provides detailed information on molecular weight and structural arrangements. These biophysical techniques are essential for glycomics, allowing researchers to identify and quantify sugars in various biological samples with high accuracy.

115. (A) Both A and R are true and R is the correct explanation of A.
Standard cloning vectors like plasmids and bacteriophages are limited in the size of foreign DNA they can accommodate, typically carrying fragments under fifty thousand base pairs. To overcome this, specialized vectors like yeast artificial chromosomes and bacterial artificial chromosomes were developed. These vectors can stably carry and replicate much larger inserts, ranging from hundreds of thousands to millions of base pairs, which is essential for mapping large genomes.

116. (D) enhance the nutritional value of rice (pro-vitamin A).
Golden Rice is a genetically engineered variety of rice designed to address vitamin A deficiency in developing nations. By introducing genes from maize and bacteria, researchers enabled the rice plant to produce beta-carotene, a precursor of vitamin A, in the edible endosperm. This application of agricultural biotechnology aims to provide a sustainable source of essential nutrients through a staple crop, potentially improving public health outcomes globally.

117. (A) all public knowledge and disclosures existing before a patent filing.
In intellectual property law, prior art refers to all information that has been made available to the public in any form before a given date, usually the filing date of a patent application. This includes previous patents, scientific publications, and public demonstrations. Examiners use prior art to determine if an invention is truly new and non-obvious, which are fundamental requirements for granting a legal patent.

118. (C) thermostability (resistance to high temperatures).
Taq polymerase is a specialized DNA polymerase isolated from the thermophilic bacterium Thermus aquaticus. Its most notable characteristic is its exceptional thermostability, which allows it to remain functional even after exposure to the high temperatures required for

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86. (B) increase the contrast of structures in electron microscopy.
Heavy metals like lead and uranium are used as stains in electron microscopy because they possess high atomic numbers and are electron-dense. When applied to tissue sections, these metals bind to specific cellular components, such as proteins and lipids. This selectively increases the scattering of electrons in those areas, thereby significantly enhancing the contrast and visibility of delicate cellular ultrastructures in the resulting image.

87. (D) A genomic library contains introns, while a cDNA library does not.
A genomic library contains the entire DNA sequence of an organism, including both exons and non-coding introns. In contrast, a cDNA library is created from mature messenger RNA, which has already undergone splicing to remove introns. Therefore, a cDNA library consists only of the continuous coding sequences of the genes that were being expressed in the tissue at the time of isolation.

88. (A) impart a uniform negative charge and denature the proteins.
Sodium dodecyl sulfate is an anionic detergent added to protein samples during electrophoresis to ensure separation based solely on molecular weight. It denatures proteins into linear chains and binds to them at a consistent ratio, imparting a uniform negative charge. This masks the protein's native charge and ensures that all molecules migrate toward the positive electrode at a rate determined by their size.

89. (C) Surface Plasmon Resonance (SPR)
Surface plasmon resonance is the ideal technique for studying real-time binding kinetics between molecules without the need for fluorescent or radioactive labels. It monitors changes in the refractive index near a sensor surface as molecules interact. This provides precise data on the association and dissociation rates of a drug binding to its target, allowing for a detailed understanding of the molecular interaction's strength and stability.

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90. (A) Distinguishing between different chemical environments of nuclei.
In nuclear magnetic resonance spectroscopy, differentiation refers to the ability to distinguish between atomic nuclei based on their specific chemical environments. Each nucleus experiences a unique local magnetic field depending on the surrounding atoms and bonds, which shifts its resonance frequency. This phenomenon, known as chemical shift, allows researchers to identify different functional groups and determine the precise connectivity and structure of the biomolecule.

91. (D) Immunocytochemistry or Immunofluorescence.
Immunocytochemistry and immunofluorescence are techniques used to detect and localize specific molecules within cells using antibodies. By labeling the antibodies with an enzyme or a fluorescent dye, researchers can visualize the distribution of target proteins under a microscope. These methods provide critical spatial information about cellular components, helping to identify how proteins are organized and how they function within the complex architecture of a cell.

92. (B) To synthesize new DNA strands using the template and primers.
The primary role of DNA polymerase in a PCR reaction is to catalyze the synthesis of new DNA strands. It achieves this by reading the single-stranded DNA template and adding complementary dNTPs to the 3' end of the primers. In PCR, a thermostable version of this enzyme is required to survive the high temperatures used during the denaturation phase of each cycle.

93. (C) an exclusive right to make, use, and sell the invention for a limited time.
A patent is a form of intellectual property right that provides an inventor with exclusive legal rights to their invention for a specified period, typically twenty years. This protection prevents others from making, using, or selling the patented technology without permission. In biotechnology, patents are essential for protecting investments in research and development, particularly for new drugs, gene sequences, and genetically modified organisms.

is rotated at high speeds, the centrifugal force causes particles to move outward at different rates based on these properties. This allows for the effective separation of cellular components, such as nuclei, mitochondria, and proteins, from a complex biological mixture based on their sedimentation rates.

127. (A) initial generation of the image from the specimen.
Image processing refers to the digital manipulation of images after they have been captured by a detector. It is used for enhancing contrast, reducing noise, and performing complex three-dimensional reconstructions from two-dimensional slices. While it is essential for analyzing and quantifying microscopic data, image processing cannot perform the initial physical generation of the image, which is the role of the microscope's optical or electronic system.

128. (C) maximum absorbance.
In UV-Visible spectroscopy, the lambda max represents the specific wavelength at which a substance exhibits its highest level of light absorption. Performing a wavelength scan allows researchers to identify this peak, which is characteristic for each molecule. Measuring absorbance at lambda max ensures the highest sensitivity and accuracy when quantifying the concentration of a sample, as minor changes in concentration produce the largest change in signal.

129. (B) It must contain at least one unpaired electron.
Electron spin resonance spectroscopy is a technique used to study molecules that possess at least one unpaired electron. These paramagnetic species, such as free radicals or certain metal ions, interact with an external magnetic field and absorb microwave radiation. This method provides detailed information about the electronic structure and local environment of the unpaired electron, making it invaluable for studying redox processes and enzyme mechanisms.

130. (D) I, II and III
Blotting techniques are fundamental molecular tools used to detect specific biological macromolecules. Southern blotting is designed to identify specific DNA sequences, while Northern blotting is used for RNA analysis. Western blotting utilizes the specificity of antibodies to detect and quantify proteins within a sample. Together, these three methods allow researchers to study genetic information, gene expression, and protein production with high specificity and sensitivity in various biological contexts.

131. (C) oligo(dT) affinity chromatography.
Most eukaryotic messenger RNA molecules possess a unique poly-A tail at their 3' end. This feature is exploited in mRNA purification using oligo(dT) affinity chromatography. The sample is passed through a column containing immobilized short chains of deoxythymidine, which base-pair specifically with the poly-A tails of the mRNA. Non-targeted RNA molecules, such as ribosomal and transfer RNA, do not bind and are washed away.

132. (D) transformation.
Transformation is the molecular process by which a bacterial cell takes up foreign DNA, such as a recombinant plasmid, from its surrounding environment. In the laboratory, this is often achieved by making cells "competent" using chemical treatments or electrical pulses. Once inside, the plasmid can replicate and express its genes, allowing researchers to produce recombinant proteins or maintain and study the cloned DNA within a host system.

133. (A) produced by a single B-cell clone (hybridoma).
Monoclonal antibodies are homogenous because they are produced by a single clone of identical B-cells, often through hybridoma technology. Because every cell in the clone is genetically identical, they all produce the exact same antibody molecule. This resulting population of antibodies recognizes only one specific epitope on an antigen, providing extremely high specificity and consistency for use in diagnostic tests, research assays, and targeted medical therapies.

134. (B) internal complexity or granularity.
In flow cytometry, side scatter is the measurement of light that is deflected at large angles as a cell passes through a laser. The intensity of this scattered light is primarily influenced by the internal complexity of the cell, including the presence of organelles, granules, and nuclear shape. By analyzing side scatter, researchers

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can distinguish between different types of white blood cells based on their internal structural features.

135. (B) a gene is replaced by another gene or a modified version.
A "knock-in" mouse is a genetically engineered model where a specific gene is replaced by a different gene or a modified version of the original. This is typically achieved using homologous recombination in embryonic stem cells. Unlike a knockout, which simply removes gene function, a knock-in allows researchers to study the effects of specific mutations or to express a reporter gene under a native promoter.

136. (A) large capacity for foreign DNA.
Bacterial artificial chromosomes and yeast artificial chromosomes are specialized vectors developed to overcome the size limitations of traditional plasmids. Their primary advantage is their enormous carrying capacity, allowing for the cloning of DNA fragments ranging from hundreds of thousands to over a million base pairs. This capability was essential for the Human Genome Project and continues to be vital for studying large genomic regions and complex regulatory networks.

137. (C) developing GM trees with faster growth or disease resistance.
Biotechnology in forestry focuses on the genetic improvement of tree species to enhance productivity and sustainability. This includes the development of genetically modified trees that exhibit traits such as accelerated growth rates, improved wood quality, or increased resistance to pests and diseases. These advancements aim to meet the rising global demand for timber and paper products while potentially reducing the pressure on natural forest ecosystems.

138. (D) minisatellite DNA.
Variable number tandem repeats are a type of minisatellite DNA found throughout the human genome. They consist of short sequences of nucleotides that are repeated multiple times in tandem. The number of repeats at a specific locus varies significantly between individuals, creating unique genetic patterns. These variations are the basis for DNA fingerprinting, providing a highly reliable method for forensic identification and establishing biological relationships between individuals.

139. (C) glass electrode sensitive to H+ ions.
A pH meter functions by measuring the electrical potential difference between two electrodes submerged in a solution. The key component is the glass electrode, which possesses a specialized membrane sensitive to hydrogen ion activity. As the concentration of H+ ions changes, the potential at the glass surface varies relative to a stable reference electrode. This voltage difference is then converted into a standard pH value for the researcher to read.

140. (A) IV, II, I, III
Western blotting is a sequential technique for protein detection. The process begins with separating proteins based on size using SDS-PAGE. These separated proteins are then transferred from the gel to a solid membrane. The membrane is then incubated with a primary antibody that binds specifically to the target protein. Finally, a labeled secondary antibody is added to bind the primary antibody and generate a detectable signal for visualization.

141. (D) phase contrast uses phase shifts, whereas dark-field uses light scatter.
Phase contrast and dark-field microscopy are both used to visualize unstained specimens, but they rely on different physical phenomena. Phase contrast microscopy exploits small shifts in the phase of light passing through a sample to create contrast. Dark-field microscopy, however, uses a special condenser to block direct light, ensuring that only light scattered or reflected by the specimen enters the objective lens, resulting in a bright image on a dark background.

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142. (B) provide a sterile environment for cell culture work.
A laminar air flow hood is essential in biological research to maintain a sterile working environment. It operates by passing air through a high-efficiency particulate air filter and then blowing it in a smooth, unidirectional stream across the work surface. This constant flow prevents contaminants from entering the area, protecting sensitive cell cultures and media from bacteria, fungi, and other airborne particles that could compromise experimental results.

143. (C) X-ray Crystallography
X-ray crystallography is a high-resolution biophysical technique used to determine the precise three-dimensional atomic structure of a molecule. It relies on the diffraction pattern produced when a monochromatic beam of X-rays passes through a crystallized sample. By analyzing the angles and intensities of the diffracted beams, researchers can calculate the electron density and build an accurate model showing the spatial arrangement of every atom within the molecule.

144. (D) The primary antibody
In a sandwich ELISA, a specific primary antibody, often called a capture antibody, is immobilized on the surface of the microtiter plate wells. When the sample is added, the target antigen binds to this immobilized antibody. Subsequently, a second labeled antibody is added, which binds to a different epitope on the same antigen. This "sandwiching" of the antigen between two antibodies provides high specificity and sensitivity for quantification.

145. (A) study the function of a gene by observing the effects of its absence.
Knockout mice are powerful research tools where a specific gene has been permanently inactivated. By comparing these mice to normal counterparts, scientists can observe the resulting phenotypic changes and physiological defects. This direct observation allows researchers to deduce the essential biological functions and roles of the gene in development, disease, and health, providing critical insights that are often applicable to understanding human biology and genetic disorders.

146. (B) Escherichia coli
A bacterial artificial chromosome is a specialized cloning vector derived from the F-plasmid of Escherichia coli. The F-plasmid naturally carries the genes required for its own replication and partitioning, allowing it to maintain a low copy number and accommodate very large fragments of foreign DNA stably. BACs are widely used in genomic research because they can carry inserts up to three hundred thousand base pairs within a bacterial host.

147. (B) It forms phosphodiester bonds to join DNA fragments.
DNA ligase is an essential enzyme used in molecular cloning to permanently join DNA fragments together. It catalyzes the formation of a phosphodiester bond between the 3'-hydroxyl group of one nucleotide and the 5'-phosphate group of another. This reaction repairs nicks in the DNA backbone and allows a foreign DNA insert to be covalently linked into a linearized vector, creating a stable recombinant DNA molecule.

148. (A) development of herbicide-resistant crops.
Biotechnology has revolutionized immunology through the development of diagnostic tools like ELISA, the production of highly specific monoclonal antibodies, and the creation of advanced vaccines. These applications directly utilize or target the immune system for healthcare and research. In contrast, the development of herbicide-resistant crops is an application of agricultural biotechnology focused on enhancing plant traits and farming efficiency, having no direct relation to immunological science or techniques.

149. (C) living organisms or their components to make products.
The term biotechnology refers to the application of biological systems and living organisms, or their derivatives, to create or modify products and processes for specific uses. This encompasses a broad range of activities, from traditional fermentation used in food production to advanced genetic engineering used in medicine and agriculture. At its core, it involves harnessing the natural capabilities of life to solve problems and benefit human society.

150. (A) Both A and R are true and R is the correct explanation of A.
Two-dimensional gel electrophoresis offers superior resolution because it separates proteins based on two independent physical properties. In the first dimension, proteins are resolved according to their unique isoelectric point using a pH gradient. In the second dimension, they are separated by molecular mass using SDS-PAGE. This dual-step process can distinguish between thousands of individual proteins that might

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otherwise overlap in a standard one-dimensional separation.

151. (D) Lower magnification and resolution.
While light microscopy is invaluable for observing living cells and using colored stains, its resolution is fundamentally limited by the wavelength of visible light. This prevents it from visualizing the extremely small structures within a cell, such as ribosomes or detailed membrane architecture. Electron microscopy, which uses a beam of electrons with a much shorter wavelength, provides significantly higher magnification and resolution, revealing the intricate ultrastructure of biological specimens.

152. (B) its net charge is zero.
In isoelectric focusing, proteins are subjected to an electric field within a gel that has a stable pH gradient. As a protein migrates, its net electrical charge changes according to the surrounding pH. The protein will continue to move until it reaches the specific point in the gradient where the pH equals its isoelectric point. At this point, the protein has a net charge of zero and stops migrating.

153. (C) the name of its inventor, Edwin Southern.
Southern blotting is named after the British biologist Edwin Southern, who developed the technique in 1975 for detecting specific DNA sequences. Interestingly, this naming convention led to the playful naming of other subsequent blotting techniques. Northern blotting was named for RNA detection, and Western blotting for protein detection, despite these terms being geographical references rather than the names of their respective inventors.

154. (D) Reverse Transcriptase
To generate a cDNA library, researchers must first isolate mRNA from a cell. The enzyme reverse transcriptase is essential because it uses the single-stranded mRNA as a template to synthesize a complementary DNA strand. This step is critical for converting transient and fragile RNA into stable DNA copies that can be cloned into vectors, allowing for the study and manipulation of the organism's expressed genetic information.

155. (A) A Yeast Artificial Chromosome (YAC)
A yeast artificial chromosome is the most suitable vector for constructing a genomic library of an organism with a large genome, such as a human. YACs are uniquely designed to carry extremely large inserts of foreign DNA, often exceeding a million base pairs. This high capacity significantly reduces the total number of clones required to represent the entire genome, making large-scale mapping and sequencing projects more manageable and efficient.

156. (B) Agrobacterium tumefaciens.
The genetic engineering of plants often utilizes the Ti plasmid, which is naturally found in the soil bacterium Agrobacterium tumefaciens. In nature, Agrobacterium uses this plasmid to transfer a portion of its DNA into the plant genome. Scientists have modified this system by removing the disease-causing genes and replacing them with genes of interest, creating a highly effective tool for introducing foreign traits into plants.

157. (B) gain commercial advantage and recoup research and development costs.
Patenting a biotechnological invention provides the inventor with a period of exclusive legal rights to the technology. This commercial advantage is crucial in the biotechnology industry, as research and development for new products, such as life-saving drugs or advanced agricultural seeds, are often extremely expensive and time-consuming. Patents allow companies to recoup these costs and generate profits, which incentivizes further innovation and investment in the field.

158. (A) the denaturation step, at ~95°C, would destroy a normal polymerase.
The polymerase chain reaction involves repeated cycles of heating and cooling. During the denaturation step, the temperature is raised to approximately 95°C to separate the DNA strands. This extreme heat would permanently denature most standard enzymes. Therefore, a thermostable DNA polymerase, such as Taq polymerase, is essential because it can survive these high-temperature intervals and remain active for the subsequent synthesis of new DNA strands.

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159. (C) RNA is single-stranded and requires denaturing conditions to prevent secondary structures.
RNA analysis by gel electrophoresis differs from DNA analysis primarily because RNA is single-stranded and tends to form complex secondary structures through internal base-pairing. To ensure that RNA molecules are separated strictly based on their length, denaturing agents such as formaldehyde are added to the gel. This keeps the RNA in a linear, unfolded state during the run, allowing for the accurate determination of its molecular weight and size.

160. (A) P-3, Q-4, R-1, S-2
Molecular techniques are defined by their unique core principles for analyzing biological molecules. PCR is used for the in vitro amplification of DNA sequences, while RFLP relies on the digestion of DNA with restriction enzymes. FISH involves the hybridization of fluorescent probes to specific chromosomal locations, and ELISA uses enzymatic detection of antigen-antibody complexes. Together, these methods provide a comprehensive set of tools for modern genetic and biochemical research.

161. (A) aromatic amino acids like tryptophan and tyrosine.
Proteins exhibit a characteristic absorbance peak at 280 nanometers when measured with a UV spectrophotometer. This absorption is primarily due to the presence of aromatic amino acids, specifically tryptophan and tyrosine, within the protein's primary structure. By measuring the intensity of this peak, researchers can rapidly and non-destructively estimate the concentration of a purified protein sample, provided the extinction coefficient is known for that specific protein.

162. (D) absorbs light and emits light of a longer wavelength.
Fluorescence is a physical phenomenon where a molecule, known as a fluorophore, absorbs light at a specific shorter wavelength and then almost instantaneously emits light at a longer wavelength. This shift in wavelength, known as the Stokes shift, is what allows researchers to visualize specific structures in fluorescence microscopy. By using filters to block the excitation light, only the emitted fluorescent signal is observed, providing high contrast and specificity.

163. (B) Light and electron microscopy
A microtome is a specialized precision instrument used to cut extremely thin sections of biological specimens, which is a vital step in sample preparation for both light and electron microscopy. These thin slices are necessary to allow light or electrons to penetrate the sample, ensuring that the internal cellular architecture can be visualized at high resolution. Without proper sectioning, many specimens would be too opaque for detailed microscopic analysis.

164. (C) RFLP analysis.
Protein purification involves a variety of chromatographic techniques, such as ion-exchange, gel filtration, and affinity chromatography, which separate proteins based on their charge, size, or specific binding properties. These methods are designed to isolate a target protein from a complex mixture. In contrast, RFLP analysis is a genetic technique used to study variations in DNA sequences and is not used for the physical purification of proteins from biological samples.

165. (D) I, II and III
Gene knockout technology is a powerful reverse genetics approach used to determine the function of a gene by observing the effects of its absence. This process can be performed in both prokaryotic and eukaryotic organisms. It frequently employs homologous recombination to precisely replace a functional target gene with an inactive DNA construct. This allows researchers to study the resulting phenotypic changes and deduce the gene's essential biological roles.

166. (B) Techniques like Electrospray Ionization (ESI) and similar interfaces.
Electrospray ionization is a soft ionization technique in mass spectrometry that is particularly well-suited for coupling with liquid chromatography. It allows for the continuous analysis of components as they elute from the chromatography column by converting the liquid stream into a fine aerosol of charged droplets. This tandem approach, often called LC-MS, is a powerful tool for analyzing complex biological mixtures and identifying proteins or metabolites with high sensitivity.

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167. (D) expression of antibody fragments (intrabodies) within the cell.
Detecting molecules in living cells poses a challenge because standard antibodies cannot easily cross the intact cell membrane. To overcome this, researchers can use genetic engineering to express antibody fragments, known as intrabodies, directly within the target cell. These intrabodies can be fused to fluorescent proteins, allowing for the real-time visualization of protein localization and dynamics in a truly living, functioning cellular environment without the need for fixation or permeabilization.

168. (A) samples a larger genomic portion and is more reproducible than RAPD.
Amplified fragment length polymorphism offers several advantages over other molecular marker techniques. It samples a much larger number of loci across the entire genome in a single assay compared to RFLP. Furthermore, because it uses specific adapters and highly selective primers, it is significantly more reproducible than RAPD. This combination of high resolution and reliability makes AFLP an excellent tool for genetic mapping and biodiversity studies in diverse species.

169. (C) To facilitate the delivery of the cloned DNA into bacterial host cells.
In a phage vector, the components derived from a bacteriophage are used to package the recombinant DNA into viral particles. This packaging process is highly efficient and allows the cloned DNA to be delivered into bacterial host cells through the natural infection mechanism of the virus. This method provides a much higher efficiency of gene transfer compared to standard chemical or electrical transformation methods used for plasmids.

170. (A) resistance to certain insect pests.
Bt corn is a transgenic plant that has been modified to express an insecticidal protein derived from the soil bacterium Bacillus thuringiensis. This protein, known as the Bt toxin, is specifically toxic to certain insect pests like the European corn borer but is harmless to humans and other animals. This application of biotechnology reduces the need for external chemical pesticides, promoting more sustainable and efficient agricultural practices.

171. (D) It requires staining the specimen with heavy metals.
Phase contrast microscopy is a highly effective technique for observing unstained, living specimens by exploiting differences in their refractive index. It uses specialized optics, including a phase plate, to convert phase shifts into visible changes in contrast. Unlike electron microscopy, which often requires staining with heavy metals for visibility, phase contrast allows biological samples to be viewed in their native state, preserving their structural and functional integrity during observation.

172. (B) internal face of cellular membranes.
The freeze-fracture technique is uniquely suited for studying the internal structure of cellular membranes. When a frozen specimen is fractured, the crack often travels through the hydrophobic interior of the lipid bilayer, splitting the membrane into two halves. This exposes the internal faces of the membrane, allowing researchers to observe the distribution and density of integral membrane proteins using electron microscopy. This provides a detailed view of membrane organization.

173. (C) the absorbance or transmittance of light by a colored solution.
A colorimeter is an instrument used to determine the concentration of a solute in a solution by measuring its absorbance of a specific wavelength of light. It works on the principle that the intensity of the color of a solution is directly proportional to the concentration of the dissolved substance. This simple and effective tool is widely used in biochemical assays and clinical laboratories for quantifying various molecules and monitoring reactions.

174. (D) Light microscopy
Biophysical methods involve the application of physical principles and techniques to study biological systems at the molecular level. Techniques like NMR, X-ray crystallography, and SPR provide detailed information on molecular structure, dynamics, and interactions. While light microscopy is an essential tool in biology for visualizing cells and tissues, it is generally classified as an imaging technique rather than a specialized biophysical method for the structural analysis of individual molecules.

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175. (A) left and right circularly polarized light.
Circular dichroism spectroscopy measures the difference in the absorption of left-handed and right-handed circularly polarized light by chiral molecules. Because biological macromolecules like proteins and DNA are chiral, they produce characteristic CD spectra that reflect their secondary structure content. This allows researchers to rapidly determine the percentage of alpha-helices or beta-sheets in a protein and monitor structural changes caused by environmental factors or mutations.

176. (B) A technique using an antibody to specifically pull down its antigen.
Immunoprecipitation is a targeted purification technique used to isolate a specific protein from a complex mixture, such as a cell lysate. It relies on the high affinity and specificity of an antibody for its antigen. The antibody is added to the mixture, binds to the target protein, and then the resulting complex is precipitated using specialized beads. This method is essential for studying protein expression and identifying interacting molecular partners.

177. (B) a synthetic primer containing the specifically desired mutation.
In vitro mutagenesis is used to create specific changes in a DNA sequence. This process requires a synthetic oligonucleotide primer that is designed to be complementary to the target gene but contains one or more mismatched bases representing the desired mutation. During PCR amplification, this primer is incorporated into the new DNA strands, effectively replacing the original sequence with the mutated version for subsequent functional analysis and study.

178. (A) Restriction Fragment Length Polymorphism
Restriction fragment length polymorphism refers to variations in the lengths of DNA fragments produced when a genomic sample is digested with specific restriction enzymes. These length differences result from mutations that create or destroy recognition sites for the enzymes. By separating the fragments using gel electrophoresis and visualizing them with a probe, researchers can create a unique genetic pattern used for mapping and individual identification.

179. (C) visualize the DNA under UV light.
Ethidium bromide and SYBR Green are fluorescent dyes used in gel electrophoresis to visualize DNA. These molecules intercalate between the bases of the DNA double helix. When the gel is exposed to ultraviolet light, the bound dye fluoresces brightly, allowing researchers to see the position and intensity of the DNA bands. This is essential for determining the size and quantity of DNA fragments after they have been separated by the gel.

180. (D) Saccharomyces cerevisiae (yeast).
A yeast artificial chromosome is a specialized vector designed to carry and replicate very large DNA fragments in the budding yeast, Saccharomyces cerevisiae. To function correctly, a YAC must include essential chromosomal elements such as telomeres for end protection, a centromere for proper segregation during cell division, and an origin of replication. These features allow the YAC to be maintained as a stable, linear chromosome within the yeast host cell.

181. (C) recombinant vectors that contain the entire genome of an organism.
A genomic library is a comprehensive collection of recombinant clones that together represent the entire genetic material of an organism. To create a library, the total genomic DNA is fragmented and each piece is inserted into a cloning vector, such as a plasmid or BAC. This collection of clones serves as a permanent and searchable resource for isolating specific genes, studying regulatory sequences, and mapping the entire genome of a species.

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182. (B) the potential for unintended ecological consequences of releasing GMOs.
One of the primary ethical concerns in genetic engineering is the potential environmental impact of releasing genetically modified organisms into the wild. There are fears that modified traits, such as herbicide resistance, could spread to wild relatives through cross-pollination, creating "superweeds." Additionally, there are concerns about the effects on non-target species and the disruption of local ecosystems, requiring thorough risk assessment and strict regulatory oversight for any GMO release.

or emitted electrons, providing a detailed three-dimensional view of the external topography. Both offer much higher resolution than standard light-based microscopes.

215. (D) information about the chemical environment and atomic connectivity.
Nuclear magnetic resonance spectroscopy provides sophisticated information about the internal structure of a molecule. It detects the magnetic properties of atomic nuclei, which are influenced by their surrounding chemical environment. The resulting spectrum reveals how atoms are connected and their spatial proximity to one another. This allows researchers to determine the precise three-dimensional structure of proteins and other macromolecules in their native solution state, which is essential for understanding their biological function.

216. (A) colored product.
The final stage of an ELISA involves adding a specialized substrate that is recognized by the enzyme conjugated to the detection antibody. The enzyme catalyzes a chemical reaction that converts the colorless substrate into a brightly colored product. The intensity of this color is directly proportional to the amount of antigen present in the original sample, which can be quantified using a spectrophotometer to provide a precise numerical result for the assay.

217. (C) determine the function of the gene by observing phenotypic absence.
A gene knockout is a foundational tool in genetics used to determine a gene's biological role. By permanently inactivating a specific gene, researchers can observe what happens to the organism in its absence. The resulting changes in appearance, behavior, or health provide direct evidence of the gene's essential functions. This "loss-of-function" approach is critical for understanding how genes contribute to normal development and how their failure leads to various genetic diseases.

218. (D) it provides a much greater separation and resolution of proteins.
Two-dimensional gel electrophoresis is superior to one-dimensional methods because it separates proteins using two independent criteria. By resolving proteins first by their isoelectric point and then by their molecular weight, it can distinguish between molecules that would otherwise appear as a single band. This high resolution allows researchers to identify and analyze thousands of individual protein spots in a single experiment, making it a powerful tool for global proteomic studies and biomarker discovery.

219. (A) probe.
A probe is a labeled molecule, usually a single-stranded DNA or RNA fragment, used to identify specific nucleic acid sequences in a sample. It works through the principle of hybridization, where the probe base-pairs with its complementary target sequence. The label, which can be radioactive or fluorescent, allows researchers to detect and localize the target sequence within a complex mixture, such as on a blotting membrane or within a tissue section.

220. (A) Both A and R are true and R is the correct explanation of A.
A cDNA library is significantly smaller and less complex than a genomic library from the same eukaryotic organism. This is because cDNA is synthesized only from the messenger RNA present in a cell, representing the exons of genes being actively expressed. In contrast, a genomic library contains every DNA sequence, including large non-coding regions such as introns and intergenic spaces, which make up the vast majority of many eukaryotic genomes.

221. (D) agriculture and horticulture.
The use of Agrobacterium tumefaciens as a vector is a fundamental application of biotechnology in agriculture and horticulture. This bacterium has the natural ability to transfer DNA into plant cells, which scientists have harnessed to introduce beneficial traits. These include increased crop yields, resistance to pests and diseases, and improved flower characteristics. This technology has become an essential tool for the precise and efficient genetic improvement of a wide variety of economically important plant species.

222. (B) It uses a single, short, arbitrary primer.
Random amplified polymorphic DNA is a PCR-based technique characterized by the use of a single, short primer with an arbitrary sequence. Because the primer is not specific to any known

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protein for various medical, industrial, or scientific applications.

191. (B) A small, circular, extrachromosomal DNA molecule found in bacteria.
A plasmid is a small, double-stranded, circular DNA molecule that exists independently of the chromosomal DNA in bacterial cells. Plasmids often carry genes that provide an advantage, such as antibiotic resistance, and can replicate on their own. In biotechnology, plasmids are modified to serve as versatile cloning vectors, providing a convenient way to insert, maintain, and express foreign DNA fragments within a bacterial host.

192. (D) use biological agents to improve food quality, safety, and production.
Biotechnology in the food industry utilizes biological agents like enzymes and microorganisms to enhance various aspects of food production. This includes the use of fermentation to improve flavor and shelf-life, the application of enzymes for processing, and the development of sensitive tests to ensure food safety. By harnessing these biological processes, the industry can create higher-quality products more efficiently while meeting the nutritional demands of a growing global population.

193. (A) smaller molecules enter the pores of the beads and elute last.
Gel filtration, also known as size-exclusion chromatography, separates molecules based on their physical size. The column is filled with porous beads. Small molecules can enter these pores and follow a longer, more circuitous path, while large molecules are excluded and move more rapidly through the spaces between the beads. Consequently, the largest molecules elute from the column first, while the smallest molecules are the last to be collected.

194. (C) RNA polymerase
A typical PCR reaction requires several key components: a DNA template containing the target sequence, two primers to define the amplification region, dNTPs as building blocks, and a thermostable DNA polymerase to synthesize the new strands. While RNA polymerase is essential for transcription within a cell, it is not used in PCR. Instead, DNA polymerase is specifically required to catalyze the enzymatic duplication of the DNA template during the temperature cycles.

195. (B) P-4, Q-3, R-1, S-2
Different cloning vectors are chosen based on the size of the DNA fragment being cloned. Standard plasmids typically carry small inserts under 15 kb. Bacteriophage lambda vectors can accommodate larger fragments up to 25 kb. Cosmids, which are hybrid vectors, handle inserts between 35 and 45 kb. For very large genomic projects, bacterial artificial chromosomes are used, as they can stably carry and replicate inserts of up to 300 kb within a host.

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196. (D) generate contrast to visualize specific molecules or structures.
Fluorescence is utilized in microscopy to provide high contrast and specificity when observing biological samples. By labeling specific molecules, such as proteins or DNA, with fluorescent tags, researchers can make them glow brightly against a dark background. This allows for the precise visualization of individual cellular components that would be otherwise invisible or indistinct in standard bright-field microscopy, helping to map their location and organization within the cell.

197. (A) Both Statement I and Statement II are true.
Spectroscopy is a vital analytical tool in biochemistry. UV spectroscopy is commonly used to estimate protein concentration by measuring the absorbance of aromatic amino acids at 280 nm. Visible spectroscopy is employed for colorimetric assays, such as the Bradford assay, where a dye binds to proteins and changes color. By measuring the light absorbed at specific wavelengths, researchers can accurately determine the amount of biological material present in a sample.

198. (B) visualize unstained and living cells with high contrast.
The primary advantage of phase contrast microscopy is its ability to reveal detailed internal structures in unstained, living cells. In standard bright-field microscopy, these transparent samples provide very little contrast and are difficult to see without lethal staining. Phase contrast overcomes this by converting minute phase shifts caused by the specimen into visible variations in light intensity, allowing researchers

to observe dynamic cellular processes in real-time without damaging the sample.

199. (C) To prevent antibodies from binding non-specifically to the membrane.
In a Western blot, the solid membrane used for protein transfer has a high affinity for all proteins. After the transfer, it is essential to "block" any remaining empty spaces on the membrane surface with a protein solution like non-fat milk. This prevents the primary and secondary antibodies from sticking non-specifically to the membrane itself, which would otherwise result in a very high background signal and obscure the specific protein bands.

200. (A) I only
Blotting techniques are specialized for different types of biological macromolecules. Southern blotting is the standard method used for the detection of specific DNA sequences. In contrast, Northern blotting is designed for the analysis of RNA, and Western blotting is used to identify specific proteins. Each technique combines gel electrophoresis with a specific transfer and detection system, providing a robust framework for analyzing the molecular components of a cell.

201. (A) the simultaneous measurement of the expression levels of thousands of genes.
Microarray analysis is a high-throughput technology that allows researchers to monitor the expression of thousands of genes at the same time. By hybridizing labeled nucleic acids from a cell to a grid of immobilized DNA probes, the technique provides a global view of gene activity under specific conditions. This "transcriptomic" profile is essential for understanding complex biological processes, such as disease development, cellular differentiation, and responses to environmental stimuli.

202. (D) isolating messenger RNA (mRNA).
The creation of a cDNA library begins with the isolation of total messenger RNA from a biological sample. Because mRNA represents only the genes that are being actively transcribed, the resulting library will contain the coding sequences of those expressed genes. Once the mRNA is isolated, it serves as the template for the enzyme reverse transcriptase to synthesize stable, double-stranded DNA copies, which are then cloned into suitable vectors for further analysis.

203. (B) Ti plasmid-based vector
The Ti plasmid, originally found in the soil bacterium Agrobacterium tumefaciens, is the most widely used vector for creating genetically modified plants. Scientists have engineered this natural DNA transfer system to deliver specific genes of interest into the plant genome. Once integrated, these genes can confer new traits such as pest resistance or improved nutrition. This method has become a foundational tool in agricultural biotechnology for the development of improved crop varieties.

204. (C) specific regions of the genome are highly variable between unrelated individuals.
DNA fingerprinting is based on the biological fact that certain regions of the human genome contain highly variable repetitive sequences. The number of these repeats differs significantly between individuals, producing a unique genetic pattern for everyone except identical twins. By analyzing several of these loci, forensic scientists can establish identity with an extremely high degree of certainty, making it an invaluable tool in criminal investigations and paternity testing.

205. (D) Radioactive
RIA stands for Radioimmunoassay, which is a highly sensitive laboratory technique used to measure the concentration of antigens, such as hormones or drugs, in a sample. It relies on the competitive binding between a radioactively labeled antigen and an unlabeled antigen from the sample for a limited number of antibody binding sites. By measuring the remaining radioactivity, researchers can accurately calculate the amount of the target molecule present in the biological fluid.

206. (A) secondary electrons emitted from the specimen's surface.
A scanning electron microscope produces detailed three-dimensional-like images by scanning a specimen's surface with a focused electron beam. As the electrons strike the sample, they cause the emission of secondary electrons from the surface. These emitted electrons are collected by a detector and used to create an image that reveals the surface topography and morphology

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with high resolution, providing a unique view of the sample's external features and textures.

207. (C) Circular Dichroism (CD) Spectroscopy
Circular dichroism spectroscopy is a powerful biophysical method for analyzing the secondary structure of proteins in solution. It measures how a protein differentially absorbs left and right circularly polarized light. Alpha-helices and beta-sheets produce distinct and characteristic CD spectra. This allows researchers to quickly determine the dominant structural motifs of a purified protein and monitor how its folding changes in response to factors like temperature, pH, or ligand binding.

208. (B) identify proteins that are interacting with the primary target.
Co-immunoprecipitation is an extension of the standard immunoprecipitation technique used to study protein complexes. While IP is used to purify a single target protein, Co-IP aims to pull down the target protein along with any other proteins that are physically associated with it under physiological conditions. This method is a critical tool for mapping the complex network of protein-protein interactions that drive cellular signaling, metabolism, and structural organization within the cell.

209. (D) creating gene knockouts in mice.
While genomic in situ hybridization is a valuable tool for chromosomal analysis in hybrids, it is not used for creating gene knockouts. Knockout technology involves the permanent inactivation of a specific gene, typically through homologous recombination or gene editing in embryonic stem cells. GISH, instead, is a visualization technique that uses total genomic DNA as a probe to identify the parental origin of chromosomes, which is essential in evolutionary biology and complex plant breeding programs.

210. (A) III, I, II, IV
Creating a recombinant plasmid is a logical, multi-step process. First, both the vector and the DNA insert must be digested with the same restriction enzyme to create compatible ends. Second, these fragments are ligated together to form a circular recombinant plasmid. Third, this plasmid is introduced into host cells through transformation. Finally, the transformed cells are grown on selective media to identify and isolate those that have successfully taken up the recombinant DNA.

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211. (D) Separating proteins by their isoelectric point.
The polymerase chain reaction is a versatile DNA amplification tool with numerous applications, including cloning, forensic analysis, and disease diagnosis. It works by exponentially duplicating specific DNA sequences. In contrast, separating proteins by their isoelectric point is achieved through isoelectric focusing, an electrophoretic technique based on the electrical properties of proteins. PCR is strictly a method for nucleic acid manipulation and cannot be used for the physical separation of proteins based on their charge.

212. (A) Intellectual Property Rights.
IPR stands for Intellectual Property Rights, which refer to legal protections granted to creators and inventors for their original works and discoveries. In the field of biotechnology, this includes patents for new drugs, modified gene sequences, and innovative laboratory techniques. These rights are essential for encouraging innovation by providing a legal framework that allows inventors to control and profit from their work, thereby driving further research and development in the industry.

213. (C) interact with mixture components to cause their individual separation.
In chromatography, the stationary phase is the material that remains fixed within the column. Its primary role is to provide a surface or matrix that interacts with the individual components of a mixture as they are carried through by the mobile phase. Because different molecules interact with the stationary phase with varying strengths, they travel at different speeds, eventually emerging from the column at different times, which results in their effective separation.

214. (B) TEM requires a thin section of the specimen, while SEM can view the surface of bulk samples.
Transmission electron microscopy and scanning electron microscopy differ in how they interact with the specimen. TEM requires extremely thin sections of a sample because the electron beam must pass through it to form an image of the internal ultrastructure. In contrast, SEM scans the surface of bulk specimens to detect reflected

183. (D) DNA ligase.
DNA ligase is a vital enzyme in both natural DNA replication and in the laboratory for recombinant DNA technology. In the cell, it performs the final step of joining Okazaki fragments on the lagging strand by sealing the nicks in the sugar-phosphate backbone. In molecular cloning, the same enzyme is used to covalently link a target DNA fragment into a linearized plasmid vector, creating a stable and continuous recombinant DNA molecule.

184. (A) the unique pattern of gel bands representing an individual's DNA.
In DNA fingerprinting, the "fingerprint" refers to the specific and unique pattern of DNA bands that appear after a sample has been processed by gel electrophoresis. This pattern represents variations in highly repetitive regions of an individual's genome. Just like a physical fingerprint, this molecular pattern is unique to each individual, allowing it to be used with high confidence in forensic investigations, paternity testing, and biodiversity research.

185. (A) Both A and R are true and R is the correct explanation of A.
Restriction enzymes are highly specific biological tools that recognize and cleave specific nucleotide sequences within double-stranded DNA. Because RNA is typically single-stranded and has a different chemical structure, these enzymes are unable to bind and cut RNA molecules. This specificity is why restriction digestion is a technique exclusively used for the manipulation and analysis of DNA, while different enzymes are required for the processing of RNA.

186. (B) wavelength of the electrons.
The resolution of any microscope is fundamentally limited by the wavelength of the radiation used for imaging. According to the laws of physics, smaller wavelengths allow for the resolution of smaller details. Because the wavelength of an accelerated electron beam is thousands of times shorter than that of visible light, electron microscopes can achieve significantly higher resolution, allowing scientists to see individual organelles and even large molecular complexes.

187. (A) create a stable pH gradient for protein separation by charge.
An isoelectric focusing gel contains specialized molecules called ampholytes that establish a stable pH gradient when an electric field is applied. This technique allows for the high-resolution separation of proteins based on their unique isoelectric point. Proteins migrate until they reach the pH where their net charge is zero. This method is particularly useful for separating protein isoforms that have identical molecular weights but differ slightly in their overall electrical charge.

188. (C) a focused laser beam.
Flow cytometry functions by suspending cells in a stream of fluid and passing them individually through a highly focused laser beam. As each cell interacts with the light, it scatters the laser and, if labeled, emits fluorescence. These signals are detected and analyzed to provide detailed information about the cell's size, internal complexity, and the presence of specific surface markers, allowing for the rapid characterization of thousands of cells.

189. (D) RAPD uses PCR with random primers, whereas RFLP uses restriction.
RFLP and RAPD are both DNA marker techniques but they rely on different principles. RFLP involves digesting genomic DNA with restriction enzymes and then using hybridization probes to detect length variations. RAPD, on the other hand, uses PCR with short, arbitrary primers that bind to multiple sites across the genome to amplify random fragments. While RFLP is more reproducible, RAPD is faster and does not require prior sequence information for the organism.

190. (C) To make host cells transcribe and translate a gene into a protein.
In the context of biotechnology, expression refers to the entire biological process where the information in a cloned gene is used to synthesize a functional protein product. This involves introducing the gene into a host cell using an expression vector that provides the necessary signals for transcription and translation. Successful expression allows researchers to produce and harvest large quantities of the

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gene, it binds to multiple locations across the genome where its sequence is accidentally complementary. This results in the amplification of a random set of DNA fragments, which produces a unique pattern that can be used for genetic mapping and biodiversity analysis without prior sequence knowledge.

223. (C) a hybrid vector containing plasmid sequences and phage 'cos' sites.
A cosmid is a specialized hybrid cloning vector designed to carry large DNA fragments. It contains essential plasmid elements, such as an origin of replication and selectable markers, along with the 'cos' sites from bacteriophage lambda. These 'cos' sites allow the recombinant DNA to be packaged into viral heads, facilitating highly efficient delivery into host bacteria. Cosmids can carry inserts up to forty-five thousand base pairs, bridging the gap between plasmids and BACs.

224. (D) Flow cytometry
Flow cytometry is a powerful technology that allows for the rapid quantitative analysis of different cell populations in a liquid sample. As cells flow individually through a laser beam, the system measures their size, complexity, and fluorescence from labeled antibodies. This multi-parametric approach can simultaneously identify and count thousands of cells based on their unique characteristics, making it essential for clinical diagnostics, immunology research, and the study of complex biological samples.

225. (A) refractive index changes near a sensor surface.
Surface plasmon resonance is a highly sensitive optical technique that measures molecular interactions in real-time. It detects minute changes in the refractive index near a gold-coated sensor surface. When target molecules bind to an immobilized ligand on the surface, the local refractive index increases, which is detected as a shift in the resonance angle of reflected light. This allows for the precise measurement of binding affinity and kinetics without using any labels.

226. (B) preserving the cells and tissues in a life-like state.
Fixation is a critical chemical or physical process in microscopy used to preserve biological specimens. Its primary goal is to halt biological activity and stabilize the cellular architecture, preventing degradation and maintaining the sample in a state that closely resembles its living condition. This ensures that the fine details of the cells and tissues remain intact during the subsequent steps of staining, sectioning, and observation under a light or electron microscope.

227. (B) ions.
In mass spectrometry, the first essential step is the conversion of neutral molecules into gas-phase ions. This ionization process is achieved using various techniques like electrospray or laser desorption. Once ionized, the molecules can be manipulated and separated by an electromagnetic field according to their mass-to-charge ratio. This allows the instrument to accurately measure molecular weight and provide detailed structural information about the components within a complex biological or chemical sample.

228. (A) antigen.
Antibody generation is the process where a host organism's immune system produces specific immunoglobulins in response to an introduced foreign substance, known as an antigen. When the antigen enters the body, it is recognized by B-cells, which then differentiate into plasma cells that secrete antibodies. These antibodies bind specifically to the antigen to neutralize it. This natural defense mechanism is harnessed in biotechnology to produce antibodies for diagnostic and therapeutic purposes.

229. (C) transcriptomics.
Transcriptomics is the study of the complete set of RNA transcripts produced by the genome under specific circumstances. Large-scale expression analysis using technologies like microarrays or RNA sequencing allows researchers to see which genes are turned on or off in a cell at any given time. This provides a comprehensive view of cellular activity and regulation, helping to understand how different biological states, such as health and disease, are reflected in the global patterns of gene expression.

230. (B) P-3, Q-4, R-1, S-2
Biotechnology involves several key terms and processes. Recombinant DNA is created by joining DNA from different sources, while a plasmid is a small circular DNA molecule used as a vector in bacteria. A transgenic organism is one

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such discrimination is a key challenge for modern legal and ethical frameworks.

261. (D) being electron-dense and scattering the electron beam.
In transmission electron microscopy, heavy metal stains like osmium and lead are used because they have high atomic numbers and are highly electron-dense. When applied to biological sections, these metals bind to specific structures like membranes or ribosomes. As the electron beam passes through the sample, these metal atoms scatter the electrons significantly more than the surrounding tissue. This creates dark, high-contrast areas in the final image, allowing the delicate ultrastructure of the cell to be visualized.

262. (B) Southern Blotting
Southern blotting is the definitive method for confirming the successful integration of a transgene into an organism's genome. By digesting the genomic DNA with restriction enzymes and then using a labeled probe specific to the transgene, researchers can visualize its presence and determine its copy number. This technique provides clear evidence that the foreign DNA has been stably incorporated into the host's genetic material, which is essential for verifying the creation of a transgenic organism.

263. (C) act as a carrier for the DNA sequence to be cloned.
The primary function of a vector in recombinant DNA technology is to serve as a reliable vehicle for carrying foreign DNA into a host cell. Vectors, such as plasmids or viral genomes, are engineered to include an origin of replication, allowing them to be copied by the host's machinery. By inserting a target gene into a vector, researchers ensure its stable maintenance and replication, which is essential for producing large quantities of the DNA or its protein product.

264. (A) Both Statement I and Statement II are true.
RAPD and AFLP are both PCR-based techniques used to create DNA fingerprints. RAPD is a simpler method that uses short, arbitrary primers to amplify random regions of the genome. AFLP is a more sophisticated and reproducible technique that combines restriction enzyme digestion with selective PCR amplification. Both methods allow researchers to analyze genetic diversity and map genomes without requiring prior knowledge of the organism's DNA sequence, though AFLP generally provides more consistent and detailed results.

265. (A) P-3, Q-4, R-2, S-1
Biological techniques employ diverse principles for the separation of molecules. SDS-PAGE resolves proteins by molecular mass, while isoelectric focusing separates them by their isoelectric point. Gel filtration uses a molecular sieve to separate by size, and ion-exchange chromatography relies on the net charge of the molecules. Understanding these fundamental physical principles is essential for selecting the appropriate method for purifying and analyzing specific proteins and other macromolecules in a complex biological sample.

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266. (B) Mass Spectrometry
Mass spectrometry is a powerful analytical tool that measures the mass-to-charge ratio of gas-phase ions. By fragmenting molecules like proteins and peptides, the instrument provides a unique pattern of peaks that can be used to determine the exact molecular weight and sequence of amino acids. Its high sensitivity and precision make it indispensable for protein identification, metabolite analysis, and studying complex chemical mixtures in clinical, forensic, and various biological research laboratories.

267. (D) to study gene function by observing results of the phenotypic absence.
The primary goal of creating a gene knockout is to determine the essential biological function of a specific gene. By permanently inactivating the gene in an organism, researchers can observe the resulting physiological or developmental defects. This "loss-of-function" evidence is critical for understanding what the gene normally does within a living system. This powerful reverse genetics approach has provided fundamental insights into development, disease mechanisms, and the complex molecular networks that sustain life.

268. (A) is made from mRNA and represents only the expressed genes.
A cDNA library is derived from messenger RNA, meaning it contains only the sequences

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238. (D) provide a 3'-OH end for DNA polymerase to initiate strand synthesis.
In a PCR reaction, primers are short, single-stranded DNA sequences that are complementary to the ends of the target DNA region. Their primary role is to bind to the template and provide a free 3'-hydroxyl group, which is essential for DNA polymerase to begin synthesizing the new strand. By defining the start and end points of the sequence to be copied, primers ensure that only the specific target region is exponentially amplified.

239. (C) DNA fragments generated by specific restriction enzyme digestion.
Amplified fragment length polymorphism is a DNA fingerprinting technique that focuses on the selective amplification of restriction fragments. The process begins with digesting genomic DNA with specific restriction enzymes and then ligating specialized adapters to the ends of the resulting fragments. PCR is then used to selectively amplify a subset of these fragments. This approach provides a high degree of resolution and reproducibility, making it an excellent tool for complex genetic mapping studies.

240. (D) I, II and III
Recombinant DNA technology relies on several types of specialized vectors. Plasmids are small circular DNA molecules that are easy to manipulate and replicate independently in bacteria. For much larger fragments, bacterial artificial chromosomes are used to accommodate hundreds of thousands of base pairs. Critically, all vectors must possess a functional origin of replication to ensure they are maintained and copied by the host cell's machinery during growth and division.

241. (A) Scanning Electron Microscopy (SEM)
To observe the detailed surface structure of a specimen like a pollen grain, scanning electron microscopy is the ideal choice. Unlike TEM, which looks through thin sections, SEM scans the surface of the object with an electron beam to create a high-resolution, three-dimensional-like image. This technique reveals intricate topographical details such as ridges, pores, and textures with incredible clarity, providing a comprehensive view of the sample's external morphology at very high magnification.

242. (D) the negative logarithm of the hydrogen ion concentration.
The pH of a solution is a fundamental chemical property that measures its acidity or alkalinity. Mathematically, it is defined as the negative logarithm to the base ten of the hydrogen ion concentration. A low pH indicates a high concentration of H+ ions, while a high pH indicates a low concentration. Maintaining a stable pH is essential for many biological processes, as it directly affects the structure and function of proteins and other macromolecules.

243. (B) electron density map.
The primary result of an X-ray crystallography experiment is an electron density map, which shows the distribution of electrons throughout the crystallized molecule. This map is generated by mathematically analyzing the diffraction pattern produced when X-rays strike the crystal. By identifying where the electron density is highest, researchers can determine the precise location of each atom, allowing them to build an accurate three-dimensional model of the molecule's structure at an atomic level of detail.

244. (C) labeled DNA or RNA probe.
In a Southern blot, the detection of a specific DNA fragment is achieved through the use of a labeled DNA or RNA probe. The probe is designed with a nucleotide sequence that is complementary to the target fragment. Through the process of hybridization, the probe binds specifically to the target DNA immobilized on the membrane. The label, which is typically radioactive or fluorescent, then allows the researcher to visualize and identify the target sequence among many others.

245. (D) create specific, predetermined changes in a given DNA sequence.
In vitro mutagenesis is a precise molecular technique that allows researchers to introduce specific, planned mutations into a DNA sequence. This targeted approach is essential for studying the functional importance of individual amino acids in a protein or specific regulatory elements in a gene. By observing how these predetermined changes affect the molecule's activity or stability, scientists can deduce the underlying rules of biological structure and function at the molecular level.

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246. (B) relative abundance, pI, and molecular weight of many proteins.
Two-dimensional gel electrophoresis provides a comprehensive snapshot of a cell's proteome by separating thousands of proteins in a single assay. It provides information on three key properties: the isoelectric point from the first dimension, the molecular weight from the second dimension, and the relative abundance based on the intensity of each spot. This high-resolution map allows researchers to compare protein expression between different samples and identify proteins involved in specific biological processes or diseases.

247. (C) DNA copy of an RNA molecule.
A complementary DNA molecule is a stable, double-stranded DNA sequence synthesized from a messenger RNA template using the enzyme reverse transcriptase. Because cDNA is derived from mature mRNA, it contains only the coding sequences, or exons, of a gene, without the non-coding introns. This makes cDNA highly valuable for cloning genes, expressing recombinant proteins in bacteria, and studying the portion of the genome that is actively translated into functional molecules.

248. (D) Recombinant DNA technology and PCR.
The "Golden Age" of biotechnology was driven by the development of two revolutionary molecular tools: recombinant DNA technology and the polymerase chain reaction. Recombinant DNA technology allowed scientists to manipulate and move genes between organisms, while PCR provided the ability to rapidly amplify any DNA sequence of interest. Together, these advancements transformed biological research, enabling unprecedented progress in medicine, agriculture, and forensic science, and laid the foundation for the modern biotechnology industry.

249. (A) genetic engineering of plants.
The development of crops resistant to glyphosate, a broad-spectrum herbicide, is a classic example of genetic engineering in agriculture. Researchers identified a bacterial gene that provides resistance to the chemical and precisely inserted it into the plant genome. This allows farmers to spray fields with glyphosate to kill weeds without harming the crop itself. This application of biotechnology has significantly changed modern farming practices, although it remains a subject of ongoing ecological and ethical debate.

250. (B) A DNA probe.
Western blotting is a technique used specifically for the detection of proteins, not DNA. It requires several key components: an SDS-PAGE gel for separation, a membrane for transfer, a primary antibody specific to the target protein, and a labeled secondary antibody for signal generation. In contrast, a DNA probe is used in Southern blotting to identify specific DNA sequences. Therefore, a DNA probe is not required for the identification of proteins in a standard Western blot.

251. (B) cutting extremely thin sections of biological material.
A microtome is a precision laboratory instrument used to cut biological specimens into extremely thin slices, often only a few micrometers thick. These sections are necessary for light or electron microscopy to allow light or an electron beam to pass through the sample, providing a clear image of internal structures. Proper sectioning ensures that the cellular architecture can be visualized at high resolution, making the microtome an essential tool for histology and cell biology.

252. (A) changes in the local environment of a fluorophore.
Fluorescence spectroscopy is a sensitive technique that provides information about the chemical environment surrounding a fluorescent molecule, or fluorophore. The intensity and wavelength of the emitted light can change depending on factors like pH, solvent polarity, or the proximity of other molecules. By monitoring these changes, researchers can study protein folding, ligand binding, and molecular dynamics in real-time, making it a valuable tool for investigating the functional behavior of biomolecules in various environments.

253. (C) move separated molecules from a fragile gel to a solid support membrane.
The transfer step, commonly known as blotting, is essential in techniques like Southern and Western blotting. It involves moving the separated DNA or protein molecules from a delicate electrophoresis gel onto a durable, solid

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support membrane, such as nitrocellulose or nylon. This immobilizes the molecules while preserving their relative positions, making them accessible for hybridization with probes or binding with antibodies. This step is necessary for the subsequent detection and identification of target molecules.

254. (D) transgenic.
A transgenic organism is one that has been genetically engineered to contain a gene, known as a transgene, from a different species. This is achieved by precisely inserting the foreign DNA into the organism's genome using recombinant DNA technology. Transgenic plants and animals are used extensively in research to study gene function, in agriculture to improve crop traits, and in medicine to produce therapeutic proteins or serve as models for various human genetic diseases.

255. (A) Both A and R are true and R is the correct explanation of A.
In size-exclusion chromatography, the separation is based on the ability of molecules to enter the pores of the stationary phase beads. Large molecules are completely excluded from these pores and simply flow around the beads, taking the shortest and fastest path through the column. Smaller molecules, however, enter the pores and follow a much longer, more tortuous path. Consequently, larger molecules are the first to emerge from the end of the chromatography column.

256. (B) The production of recombinant human insulin.
The production of recombinant human insulin is a major milestone in healthcare biotechnology. By inserting the human insulin gene into bacteria, researchers created a reliable and safe method to manufacture large quantities of the hormone for treating diabetes. This replaced the older practice of using animal insulin, which was less efficient and could cause adverse reactions. This success demonstrated the power of genetic engineering to provide effective and highly specific treatments for complex medical conditions.

257. (D) to form phosphodiester bonds between the insert DNA and the vector.
DNA ligase is an essential enzyme in molecular cloning that performs the vital task of permanently joining two DNA molecules. It catalyzes the formation of a phosphodiester bond between the sugar-phosphate backbones of the target DNA insert and the circularized plasmid vector. This covalent link creates a stable and continuous recombinant DNA molecule that can then be introduced into a host cell, where it will be replicated and maintained during cellular growth and division.

258. (A) bioremediation.
Bioremediation is the strategic use of living organisms, particularly bacteria, fungi, or plants, to clean up contaminated environments. These organisms naturally possess metabolic pathways that allow them to degrade or neutralize toxic pollutants such as heavy metals, oil, and various industrial chemicals. By harnessing these biological processes, bioremediation provides a sustainable and often more cost-effective alternative to traditional chemical or physical methods for restoring soil and water health in polluted ecosystems.

259. (C) the binding of primers to the template DNA.
The annealing step is a critical phase of the polymerase chain reaction. After the DNA template has been denatured by heat, the temperature is lowered to allow the primers to find and bind to their complementary sequences on the single-stranded DNA. This specific binding defines the target region that will be copied. Once the primers are properly annealed, the temperature is raised slightly for the DNA polymerase to begin synthesizing the new DNA strands.

260. (A) potential for genetic discrimination in various employment or insurance.
A major ethical concern in biotechnology is the potential for genetic discrimination. As DNA sequencing becomes faster and cheaper, an individual's genetic profile could be used by employers or insurance companies to assess risk based on predispositions to certain diseases. This raises significant privacy and fairness issues, as people could be unfairly treated or denied benefits based on their DNA. Protecting against

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that contains a gene from a different species. PCR is the fundamental technique used for the in vitro amplification of DNA. Together, these concepts form the basis for modern genetic engineering and molecular biological research.

231. (C) sequentially pellet organelles of decreasing size and particle density.
Differential centrifugation is a powerful technique for isolating cellular components based on their physical properties. By rotating a sample at a series of increasing speeds and durations, researchers can sequentially pellet different organelles. Larger, denser structures like nuclei settle first at low speeds. As the speed is increased, smaller components such as mitochondria, and finally ribosomes and microsomes, are collected. This systematic approach allows for the effective purification of specific organelles for further study.

232. (D) Western Blotting.
Physical separation methods such as electrophoresis, chromatography, and centrifugation rely on the physical properties of molecules, such as charge, size, and density, to achieve separation. These techniques are used to purify and isolate components from a mixture. In contrast, Western blotting is a detection technique that uses the biological specificity of antibodies to identify a particular protein after separation has occurred. While it involves separation, its primary purpose is molecular identification through immune recognition.

233. (A) location of specific DNA or RNA sequences within a cell or tissue.
In situ hybridization is a specialized molecular technique used to determine the precise spatial location of specific nucleic acid sequences. By applying a labeled DNA or RNA probe to a fixed specimen, the probe hybridizes specifically to its complementary target sequence. This allows researchers to visualize exactly where certain genes are located on chromosomes or which cells are expressing specific mRNA molecules, providing critical context for understanding gene function and cellular organization.

234. (B) isoelectric point (pI).
Isoelectric focusing is a high-resolution electrophoretic method that separates molecules, particularly proteins, based on their unique isoelectric point. In a stable pH gradient, a molecule will migrate under the influence of an electric field until it reaches the pH where its net electrical charge is zero. This point is known as its pI. This technique is extremely effective for resolving similar proteins and identifying isoforms that differ by only a single amino acid or modification.

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235. (B) ELISA
Cloning vectors are specialized DNA molecules, such as plasmids, cosmids, and yeast artificial chromosomes, used to carry and replicate foreign genetic material in host cells. Each type of vector is chosen based on its capacity for different insert sizes. In contrast, ELISA is an immunological assay used to detect and quantify proteins or antigens. It is a laboratory test, not a biological vehicle for carrying or cloning DNA sequences in a host organism.

236. (A) the protein requires specific post-translational modifications like glycosylation.
While bacterial systems are efficient and inexpensive, they lack the complex machinery needed for many human-like post-translational modifications. Animal cell culture systems are often preferred when the recombinant protein requires modifications such as specific glycosylation, folding, or phosphorylation to be biologically active. These eukaryotic hosts provide a cellular environment that ensures the final protein product has the correct structure and function needed for effective therapeutic use in humans.

237. (C) production of penicillin antibiotics from various microorganisms.
One of the earliest and most impactful applications of biotechnology in healthcare was the large-scale production of penicillin. This antibiotic is naturally produced by certain fungi. During World War II, researchers developed advanced fermentation and purification methods to manufacture penicillin in massive quantities, saving countless lives from bacterial infections. This achievement laid the foundation for the modern pharmaceutical industry and the use of microorganisms to produce life-saving medicines and therapeutic products.

that were being actively transcribed into protein at the time of isolation. This makes it much smaller and more focused than a genomic library, which contains all DNA, including non-coding regions and introns. Therefore, cDNA libraries are invaluable for identifying the specific genes involved in various biological processes and for cloning coding sequences without the complexity of large genomic fragments.

269. (C) amplify specific DNA sequences.
The polymerase chain reaction is a fundamental molecular biology technique used to make millions of copies of a specific DNA sequence in vitro. Through repeated cycles of heating and cooling, a targeted region is exponentially duplicated by a thermostable DNA polymerase. This high-sensitivity amplification allows researchers to detect and analyze DNA from extremely small samples, making PCR an essential tool for cloning, medical diagnostics, forensic investigations, and studying gene expression in various biological research projects.

270. (A) I and II only
ELISA and flow cytometry are both powerful immunotechniques used for detection and analysis. ELISA utilizes enzyme-linked antibodies for quantification, while flow cytometry can characterize and sort cells based on their unique properties. In contrast, Western blotting is used to detect proteins, not DNA sequences. Therefore, only the first two statements are correct, as they accurately describe common immunological methods for studying antigens and various cellular populations in modern laboratory research.

271. (B) Transformation
In recombinant DNA technology, transformation is the process by which a host bacterium takes up foreign DNA, such as a recombinant plasmid, from its environment. Researchers often use chemical or electrical treatments to make the cells "competent," allowing the plasmid to pass through the cell membrane. Once transformed, the bacteria can maintain, replicate, and express the new genetic material, providing a powerful system for producing proteins or studying specific genes in a controlled laboratory setting.

272. (D) provide incentives for innovation by allowing profit from various works.
Intellectual property rights are crucial for driving progress in biotechnology. By granting inventors exclusive rights to their discoveries for a set period, IPR allows companies to protect their investments and generate profits from new drugs, vaccines, and genetic technologies. This financial incentive is necessary because biotechnological research is often high-risk and extremely expensive. Without the legal protection provided by patents and other rights, many life-saving innovations would never be developed or brought to market.

273. (A) Electrophoresis
Electrophoresis is a basic laboratory technique used to separate molecules based on their electrical charge and size. When an electric field is applied to a sample of serum proteins, they migrate through a support medium at different rates. This produces a characteristic pattern of bands, such as albumin and various globulins. This simple yet effective separation method is widely used in clinical diagnostics to monitor health and identify abnormalities in a patient's protein profile.

274. (B) are transmitted through the specimen.
In a transmission electron microscope, a beam of electrons is directed at an ultra-thin section of a specimen. The image is formed by the electrons that pass through, or are transmitted by, the sample. Denser parts of the specimen scatter more electrons and appear darker, while thinner areas allow more electrons through and appear lighter. This provides an extremely high-resolution, two-dimensional view of the cell's internal ultrastructure, revealing details that are invisible to light microscopes.

275. (B) secondary structure (alpha-helix, beta-sheet).
Circular dichroism is an excellent biophysical method for monitoring changes in the secondary structure of a protein. Because proteins absorb left and right circularly polarized light differently, motifs like alpha-helices and beta-sheets produce unique and predictable spectral signatures. This allows researchers to rapidly assess a protein's overall folding and detect structural changes caused by mutations, ligand binding, or variations

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291. (D) Surface Plasmon Resonance (SPR)
Surface plasmon resonance is the best technique for studying real-time molecular interactions without the use of labels. It works by detecting changes in the refractive index near a sensor surface when molecules bind to each other. This allows researchers to monitor the binding of an antibody to an antigen as it happens, providing immediate data on the association and dissociation rates. This provides a detailed and label-free understanding of the interaction's kinetics, affinity, and overall binding strength.

292. (B) wavelength of visible light.
The resolution of a light microscope is fundamentally limited by the wavelength of visible light. According to optical physics, two points can only be distinguished as separate if they are further apart than approximately half the wavelength of the light being used. Since visible light has a relatively large wavelength, fine structures within a cell, such as ribosomes or detailed membrane architecture, cannot be resolved. To see these smaller details, techniques with shorter wavelengths, like electron microscopy, are required.

293. (C) impart a uniform negative charge and denature proteins.
Sodium dodecyl sulfate is an anionic detergent used in SDS-PAGE to ensure that proteins are separated solely by their molecular weight. It denatures the proteins into linear chains and binds to them at a consistent ratio, giving them a uniform negative charge-to-mass ratio. This masks the protein's native charge and shape, so when an electric field is applied, all proteins migrate toward the positive electrode at a speed determined exclusively by their individual size within the gel matrix.

294. (D) Microarray analysis.
To study global changes in gene expression across the entire genome, microarray analysis is the most appropriate large-scale technique. It allows for the simultaneous measurement of thousands of mRNA transcripts in a single experiment. By comparing the expression profiles of cancer cells and normal cells, researchers can identify which genes are up-regulated or down-regulated during the disease process. This provide a comprehensive view of the transcriptomic changes that drive cancer development, progression, and response to treatment.

295. (A) P-3, Q-4, R-1, S-2
Modern biological research has been built upon the work of pioneering scientists and their techniques. Edwin Southern developed the Southern blot for DNA detection, while Kary Mullis invented the polymerase chain reaction. Georges Köhler and César Milstein created the method for producing monoclonal antibodies, and Alec Jeffreys developed DNA fingerprinting for individual identification. These foundational methods and discoveries have revolutionized our ability to study and manipulate genetic information and molecular interactions at every level of biological organization.

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296. (B) an origin of replication, a selectable marker, and a cloning site.
For a plasmid to be a useful cloning vector, it must contain three essential components. An origin of replication ensures that the plasmid is copied by the host cell. A selectable marker, such as an antibiotic resistance gene, allows for the identification of transformed cells. Finally, a multiple cloning site provides a specific region with unique restriction sites where foreign DNA can be easily inserted. Together, these features make the plasmid an effective vehicle for maintaining and replicating recombinant DNA.

297. (A) in its original place.
The Latin term "in situ" translates directly to "in its original place." In biology and microscopy, it refers to techniques that allow for the detection and study of molecules or processes exactly where they occur within a native, intact environment, such as a cell, tissue section, or whole organism. This approach is invaluable because it preserves the spatial context and structural relationships between different biological components, providing insights that are often lost when molecules are purified and studied in isolation.

298. (A) I and II only
Different microscopic techniques are specialized for different levels of detail. Scanning electron microscopy is used for high-resolution imaging of a specimen's surface topography, while transmission electron microscopy is ideal for viewing internal ultrastructures at

template. In biotechnology, reverse transcriptase is an essential tool for creating cDNA libraries, allowing for the study and cloning of genes based on their mRNA.

284. (D) gene expression at the RNA level.
A Northern blot is a specialized molecular technique used to study gene expression by detecting specific RNA molecules within a sample. Similar to Southern blotting for DNA, it involves separating RNA by size using gel electrophoresis and then transferring it to a membrane. A labeled probe is then hybridized to the membrane to identify and quantify the target RNA. This method allows researchers to observe how much of a particular gene is being transcribed under different biological conditions.

285. (A) are produced by a single clone of cells and recognize a single epitope.
Monoclonal antibodies differ from polyclonal antibodies in their high degree of specificity and uniformity. Because they are produced by a single clone of identical hybridoma cells, every antibody molecule in the population is identical and recognizes the exact same epitope on an antigen. This consistency makes monoclonal antibodies invaluable for diagnostic tests, targeted therapies, and research assays where high specificity and reproducibility are required to avoid cross-reactivity with other similar biological molecules.

286. (B) To maintain a sterile working area for cell culture.
A laminar air flow cabinet is an essential piece of equipment in a biotechnology laboratory for maintaining a sterile environment. It works by blowing filtered, unidirectional air across the work surface, which creates a barrier that prevents room contaminants and airborne microbes from entering the area. This protection is critical when working with sensitive cell cultures, media, and biological samples, ensuring that experiments are not compromised by unwanted bacterial or fungal growth.

287. (B) They will be at the same vertical position but A will be to the left of B (acidic side).
In 2D gel electrophoresis, proteins are first separated by their isoelectric point along a horizontal pH gradient. Because Protein A has a lower pI of 5.0, it will stop at the more acidic end of the gel. Protein B, with a higher pI of 7.0, will stop further to the right. Since both proteins have the same molecular mass, they will migrate to the same vertical height during the second dimension. Consequently, Protein A will be located to the left of Protein B.

288. (A) it amounts to ownership of life or fundamental products of nature.
A major ethical objection to patenting genes is the philosophical argument that genetic sequences are fundamental products of nature, not human inventions. Critics argue that since genes are naturally occurring and universal to life, they should not be subject to private ownership or commercial control. Such patents are seen by some as a form of "ownership of life" and are feared to potentially restrict scientific collaboration, limit patient access to genetic testing, and stifle future research.

289. (C) FISH.
Fluorescence in situ hybridization is a powerful molecular cytogenetic technique used to detect and localize specific DNA sequences directly on chromosomes. By using fluorescently labeled probes that bind to complementary genetic targets, researchers can visualize the physical location of genes and chromosomal abnormalities under a microscope. FISH is essential for mapping the genome, identifying deletions or duplications, and studying the spatial organization of genetic material within the nuclei of fixed cells or tissue sections.

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290. (A) Both A and R are true and R is the correct explanation of A.
Expression vectors for eukaryotic cells are inherently more complex than those for bacteria because eukaryotic gene expression involves additional regulatory steps. These vectors must include signals for proper mRNA processing, such as polyadenylation sites and splicing enhancers. Furthermore, many eukaryotic proteins require specific chaperones for folding and complex post-translational modifications like glycosylation, which are not present in bacterial hosts. Therefore, eukaryotic expression systems must be carefully engineered to ensure the production of functional, biologically active proteins.

in environmental conditions like temperature and pH with high sensitivity.

276. (A) Protein A or Protein G beads.
In an immunoprecipitation experiment, specialized beads coated with Protein A or Protein G are used to capture the antibody-antigen complex. These bacterial proteins have a very high affinity for the constant region of most antibodies. When added to the mixture, the beads bind specifically to the antibodies that have already captured the target protein. By then centrifuging the solution, the heavy beads pellet at the bottom, allowing the target protein to be effectively purified.

277. (C) PCR amplification.
The key innovation that sets AFLP apart from the older RFLP technique is the addition of selective PCR amplification. While RFLP relies on hybridization probes to detect length variations in restriction fragments, AFLP uses PCR to selectively amplify a subset of fragments that have been ligated to adapters. This makes AFLP significantly faster, more sensitive, and more reproducible, allowing for high-resolution genetic fingerprinting using only a small amount of starting DNA.

278. (D) YAC (Yeast Artificial Chromosome)
A yeast artificial chromosome is the vector with the largest carrying capacity for foreign DNA. While plasmids and cosmids can handle small to medium inserts, and BACs can carry up to several hundred thousand base pairs, YACs are designed to accommodate fragments over a million base pairs long. This enormous capacity was essential for the Human Genome Project, as it allowed for the cloning of large genomic regions into a manageable number of yeast clones.

279. (C) myeloma (cancerous plasma) cell.
Monoclonal antibody production involves the fusion of an antibody-producing B-cell from an immunized animal with a myeloma cell, which is a cancerous plasma cell. The resulting hybrid cell, called a hybridoma, combines the B-cell's ability to produce a specific antibody with the myeloma's ability to divide indefinitely in culture. This allows for the continuous and large-scale production of a single, highly specific antibody that recognizes only one epitope on its target antigen.

280. (A) I, II, III, IV
Creating a genetically modified plant with Agrobacterium is a systematic four-step process. First, the gene of interest is inserted into a Ti-plasmid vector. Second, this recombinant plasmid is used to transform the Agrobacterium. Third, the modified bacteria are co-cultured with plant tissue, allowing the T-DNA to be transferred into the plant cells. Finally, the transformed cells are selected and regenerated into whole plants that stably express the new genetic trait.

281. (B) Alec Jeffreys.
The term DNA fingerprinting was coined by the British geneticist Alec Jeffreys in 1984. He discovered that certain regions of the genome contain highly variable repetitive sequences that produce a unique pattern for every individual. Recognizing its potential for identification, Jeffreys developed the first techniques to visualize these patterns. His groundbreaking work revolutionized forensic science and paternity testing, providing a scientific method to establish identity with an unprecedented degree of accuracy and certainty.

282. (A) development of diagnostic immunoassays like the standard ELISA.
Environmental biotechnology focuses on the application of biological systems to solve environmental problems, such as bioremediation, waste treatment, and the production of biopesticides. These applications directly target the health of the planet and ecosystems. In contrast, the development of diagnostic immunoassays like ELISA is an application of medical and laboratory biotechnology used for detecting diseases or molecules in a sample, having no direct relation to environmental restoration or protection processes.

283. (C) It synthesizes RNA from a DNA template.
While reverse transcriptase is used in the lab to make DNA from RNA, its natural biological role in retroviruses is to catalyze the synthesis of a DNA copy from their viral RNA genome. However, in the context of general molecular biology, the enzyme RNA polymerase is responsible for synthesizing RNA from a DNA

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high magnification. Although phase contrast microscopy is used for viewing living cells, the first two statements correctly identify the primary roles of SEM and TEM. Together, these tools provide researchers with a comprehensive set of methods for exploring both the external and internal architecture of biological specimens.

299. (D) resistant to the herbicide glyphosate.
'Roundup Ready' crops are genetically engineered plants that have been modified to tolerate the broad-spectrum herbicide glyphosate. By introducing a specific bacterial gene, researchers enabled these plants to remain healthy even when the entire field is sprayed to kill competing weeds. This application of biotechnology simplifies weed management for farmers and can lead to increased yields, although it has also raised concerns about the development of herbicide-resistant weeds and the ecological impact of intensive chemical use in modern agriculture.

300. (B) analysis by mass spectrometry.
After proteins are separated by 2D gel electrophoresis, individual spots of interest are cut from the gel for identification. The final and most definitive step in this process is typically analysis by mass spectrometry. The protein is digested into peptides, which are then analyzed to determine their exact mass-to-charge ratios. This provides a unique "peptide mass fingerprint" that can be searched against a database of known sequences to precisely identify the protein, its modifications, and its potential biological functions.

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